Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VI. NEW YORK, OCTOBER, 1901. No. 8.

DIRECT LIFT PNEUMATIC HOISTS FOR MACHINE SHOPS.

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OR

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A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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From time to time we have called attention to experiments to develop a compressed air street railway system, and the trials of systems and special machines built for this purpose have been described in detail.

In this way the history of the advance in compressed air traction may be found by referring to our files. We are glad to be able to record another advance in the form of the new motors of a compressed air company, whose works are at Rome, N. Y.

Benefiting by recent experiments, they have made a number of changes in design and construction, which tend to greatly improve their motor, and we trust that their latest form, which is now about ready to be tried, will meet with complete success. Such changes as have been made are in detail alone and do not involve any departure from the principle advocated and developed by this company. The working test given the older motors in Chicago and New York City develop certain faults in construction and it is claimed that these have been entirely removed and that the motor which is now presented will meet every condition demanded of a street railway motor.

The valve motion, which formerly gave trouble, has been somewhat simplified and considerably strengthened. The sizes of cylinders have also been increased, thus giving increased traction without an increase in mean effective pressure. By a better disposition of the storage tanks the reservoir capacity has been increased from 56 to 79 cubic feet, and we understand that this capacity is sufficient to run a car from 12 to 14 miles at a speed of 13 miles per hour, this being under service condition as to stops and character of track.

The method of attaching the motor to the truck frame has been modified and parts strengthened to more nearly resemble the system used in regular steam locomotive practice. The increase in actual diameter is also along the line of railway practice, as is likewise the use of cast steel wheels rather than cast iron. Other changes have been made, all of which are clearly described in the article given elsewhere in this issue. This is an abstract of a description appearing in the *Railroad Gazette* of September 6, to whom we are indebted for the use of the illustration herewith presented.

We sincerely trust that this new motor will meet with the success which the persistent effort of its builders warrants. The field of compressed air traction is real, and it only remains to perfect a motor which will be a permanent success as it is now possible to produce compressed air for operating such motors at a figure which is well within practical demands. In subur-

ban traffic and in many cases where long tunnels are necessary and in some cases for elevated railways, it cannot be questioned but that a compressed air motor, which will develop sufficient power with a small consumption of air and be durable, has a splendid outlook.

We will follow the future experiments with this motor with interest and endeavor to keep our readers fully posted.

Our frontispiece is an excellent illustration of the application of direct lift air hoists to modern factory operation. The picture shows the central part of a large machine shop, which is left entirely open and free to allow the use of overhead cranes for heavy material, while the pneumatic hoists, mounted on swinging booms, are arranged to cover the floor at the sides where actual construction work is done. These are large enough to lift such pieces as are used in the construction work, and in this way a machinist is entirely independent and is enabled to quickly lift parts and place them on his bench or on the special mounting frames without calling upon any of his neighbors. In the instance shown the pieces to be lifted are too heavy for one man to handle, and where formerly two men were necessary, now each machinist alone, by simply pulling a cord does the entire work. "A proof of the pudding is in the eating," and we think this illustration should answer arguments presented against the use of pneumatic hoists.

Some Facts and Figures on Compressed Air.*

Pneumatics is really that science which treats of the laws of the behavior of gases, but we usually restrict the word to that science which treats of the laws of air while in a gaseous state.

Air does not of itself possess any power or energy which we can utilize. It is an inert, dead body, just as much so as a stick or a stone. It can serve only as a transmitter of power or energy; as a means of carrying energy from a source of supply to a point of utilization, or as a body in which energy may be stored by one machine or drawn from by another.

*Abstract of a paper by Prof. J. H. Kinealy, Washington University, and published in *Cassier's Magazine* for August, 1901.

Energy may be stored in a quantity of air by heating it, or by actually doing work upon it. In either case, however, the total energy in the quantity of air is determined by its temperature, and by nothing else, so long as it remains a gas. A change in the pressure or the volume of the quantity of the air does not in any way affect the energy in it, so long as the temperature remains unchanged. That is, a pound of air at 60° Fahr. and atmospheric pressure has just as much energy, no more and no less, as a pound of air at 60° Fahr. and a pressure of 100 pounds above atmospheric pressure.

The total energy in each of the two pounds of air is exactly the same, but the available energy is very different in the two cases. In a pound of air at atmospheric pressure the available energy is almost zero, as we have no machine by which the energy in it can be utilized; but in the second pound of air the available energy, on account of the high pressure, is quite large, as we can utilize a large quantity of the energy in an ordinary air engine or motor.

In all cases the total energy in a quantity of air depends upon the heat in the air and upon nothing else; but the available energy, the energy which we can use by means of the engine or motor which we have, depends upon the difference between the pressure of the quantity of air and the pressure of the atmosphere. When work is done by a quantity of air drawn from a reservoir the heat of the air is decreased and its temperature falls, unless it receives heat from some external source during the performance of the work. And if no heat is received by the air, the decrease of heat, and, therefore, the fall of temperature also, is exactly proportional to the amount of work done or the energy taken from the air. When a quantity of air is in motion, as is the case of the air of winds or the air issuing from the outlet of a fan, it has a certain amount of energy in virtue of its motion, independent of its temperature or pressure. The energy of a pound of air at a given velocity is no more nor less than the energy which a pound of lead or rocks would have if moving at the same velocity. In the case of winds acting upon windmills, the air has been set in motion by certain physical forces and made to move with a certain velocity; when it strikes a windmill it acts upon the vanes of the wheel and does a

certain amount of work, in virtue of its velocity only.

When energy is stored in air, either by the direct giving of heat to it or by the doing of work on it, there are certain laws according to which the pressure, volume, and temperature of the air change. If one of these—pressure, volume, or temperature—changes, then one, at least, of the other two must change. It is possible, however, to keep one constant while the other two undergo a change, or a series of changes.

If the temperature is kept constant during a series of changes in the volume and pressure of a quantity of air, the relation between the volume and pressure at any instant is expressed by what is known as Boyle's law, viz., the product of the volume and pressure of a quantity of air at any one instant is equal to the product of the volume and pressure at any other instant. Another way of stating the same law is: For a quantity of air kept at a constant temperature, the volume changes inversely as the pressure. The volume may be in any units, although it is usual to express it in cubic feet; the pressure, however, must be absolute pressure or pressure counted from zero, and not the pressure above the atmosphere, as is customary when speaking of the pressure of steam in a boiler. The pressure may be pounds or ounces per square inch or per square foot, but in all cases it must be absolute pressure. The absolute pressure is equal to the pressure as indicated by the pressure gauge, commonly called the gauge pressure, plus the atmospheric pressure; and as the atmospheric pressure may for most engineering work be assumed as 15, or more exactly 14.7, pounds per square inch, the absolute pressure is equal to the gauge pressure, plus 15.

If the pressure remain constant, and the volume and temperature pass through a series of changes, the relation which exists between them during the changes is expressed by a law which is a modification of what is known as Gay Lussac's law, viz.: When the temperature and volume of a quantity of air be changed under constant pressure, the quotient obtained by dividing the volume at any one instant by the absolute temperature for the same instant is equal to the quotient obtained by dividing the volume at any other instant by the corresponding absolute temperature. This is sometimes stated thus: The quotient obtained by dividing the volume, at any instant, of a quantity of air kept at a constant pressure, by the absolute temperature at the same instant, is a constant quantity.

The absolute temperature is equal to the sum obtained by adding 461 to the temperature in Fahrenheit degrees. Thus the absolute temperature of air at 60° Fahr. is 461 plus 60, equal 521°.

From this law and Boyle's law we get the following one, which always represents the relation existing between the absolute pressure, volume, and absolute temperature of any quantity of air: The quotient obtained by dividing the product of the absolute pressure and the volume of a given quantity of air by the absolute temperature is a constant quantity. This constant quantity is equal to 0.37 times the weight, in pounds, of the given quantity of air, when the absolute pressure is in pounds per square inch, the volume in cubic feet, and the absolute temperature is measured on the Fahrenheit scale. This one law contains everything in regard to the changes of volume, pressure or temperature of a quantity of air, and it is one of the most important of all the laws of pneumatics, as upon it all the other laws are really based.

When energy is stored in a quantity of air by the direct application of heat, the temperature of the air rises, and we may at the same time let both the volume and the pressure change, or we may keep one constant and let the other change. If we keep the pressure constant and heat the air, about 0.24 of a unit of heat will be required to raise the temperature of one pound of air 1° Fahr.; while if we keep the volume constant, only about 0.17 of a unit of heat will be required to raise the temperature of one pound of air 1° Fahr. In other words, the specific heat of air at constant pressure is 1.41 times the specific heat at constant volume.

Suppose that we had one pound of air under atmospheric pressure and at a temperature of 70° Fahr., and that we gave to this air one unit of heat while its pressure remained constant. From what has been said before we are able to determine that the volume occupied by the pound of air at 70° Fahr. is about 13.3 cubic feet, that by the unit of heat its temperature would be raised about 4°, and that its volume at the temperature after the heating,

about 74°, would be about 75 per cent. greater than before the heating.

If the air were confined in a cylinder with a movable piston, as soon as the pressure rose above that of the atmosphere plus that necessary to overcome the friction of the piston in the cylinder, the piston would move upwards against the atmosphere and do work. If after the piston has moved up as far as the expansion of the air due to the unit of heat put into it would make it go, we cooled the cylinder and the air in it by means of some cool body, the air would begin to contract, and as soon as the difference between the pressure inside of the cylinder and that of the atmosphere was sufficient to overcome the friction of the piston, the atmospheric pressure would make the piston move downwards, and thus do work. This is exactly the principle employed in the Ericsson hot air engine. There, however, the pressure against which the air is made to expand is the atmospheric pressure plus the pressure necessary to overcome the friction and the resistance due to the load against which the engine is working. The air is heated by being made to come in contact with the walls of an iron cylinder which are kept hot by means of a fire; it is then made to pass into a cooling chamber at the upper part of the heating cylinder, where it is cooled by means of a water jacket.

While the air is being heated it forces the piston up, and while it is being cooled the atmospheric pressure forces the piston down. Heat is transferred from the fire to the water in the cooling packet, and during this transference a small portion of the heat given to the air by the fire is transformed into work.

If we were to give a unit of heat to a pound of air while keeping its volume constant, we should find that as its temperature increased the pressure would also increase. One unit of heat given to a pound of air at constant pressure would raise the temperature about $1.00 \div 0.17 = 6°$, so that if the temperature of the air were 70° Fahr. before the heating, it would be about 76° after the heating. If the pressure before the heating were atmospheric pressure, zero pounds by the gauge, it would be about 1.1 per cent. greater than atmospheric after the heating. That is, one unit of heat given to one pound of air at a temperature of about 70° Fahr. will increase the pressure of the air about 1.1 per cent. when the volume is kept constant, while the temperature will be increased about 6°. To increase the pressure by 11 per cent. it would be necessary to increase the temperature 60°, while keeping the volume constant. After the pressure of the air has been increased by heating, the vessel containing the air may be connected to an air-engine or motor of some kind and the air allowed to pass into it and be made to do work.

The objection to storing energy in air by giving heat to it is that, as the temperature is always increased, it is impossible to prevent radiation and conduction to neighboring bodies, and thus the heat becomes dissipated and lost. It pays to put energy in air by direct heating only when the air is to be used to do work immediately after the heating, as in the case in air-engines of the Ericsson type and those places where the air passes through the heater while on its way from a reservoir or tank in which it is at a high pressure to an air motor.

The method commonly adopted, and the best one, too, of storing energy in air is to do work on it, to compress it in an air compressor, so as to increase its pressure by decreasing its volume. As soon as we attempt to decrease the volume of a quantity of air by doing work upon it its temperature tends to increase, while its pressure also increases. By the increase of temperature the total energy in the air is increased, but after the air leaves the compressor and is stored in a tank or reservoir it will cool until its temperature becomes equal to that of the surrounding air and bodies. Therefore, all of the energy which has been put into the air as heat to increase its temperature will eventually be lost and no benefit will be derived from it. Again, the rise in temperature during the compression of the air in the compressor increases the pressure against which the piston of the compressor must be moved, and hence increases the work which must be done in compressing the air. There are, therefore, two reasons for keeping the temperature of the air during compression as nearly constant as possible.

In order to keep the temperature from rising during compression it is necessary to cool the air while in the compressor by means of water sprayed into the air or by means of a water jacket around the air cylinder of the compressor. Spraying water into the air cylinder is objectionable,

because of the large amount of moisture which is then introduced into the air, and it is, therefore, seldom done. When the air cylinder is large, and the final pressure of the air is high, it is very difficult to keep the temperature from rising by means of a water jacket, as the surface of the water jacket with which the air comes in contact is very small as compared to the volume of air in the cylinder.

When air is compressed and cooled so that there is no change of temperature during compression, we say that the compression is "isothermal compression," and that the air is compressed isothermally; but when it is compressed in a cylinder through which heat cannot pass, we say that the compression is "adiabatic compression," and that the air is compressed adiabatically. As a matter of fact, however, there is probably no actual machine which compresses isothermally; and since it is impossible to make a cylinder whose walls are not conducting, there can be no adiabatic compression in actual practice. These are simply two theoretical conditions of compression between which all compressors work. Some approach very near to the condition of isothermal compression, while others approach nearer the condition of adiabatic compression.

The work required to compress one pound of air adiabatically from atmospheric pressure and a temperature of 60° Fahr. to a gauge pressure of 90 pounds per square inch is about 1 1-3 as much as the work required to compress it isothermally, and this increased work of compression results in absolutely no benefit when using the air, unless the receiver into which the air is compressed, all the pipes through which the air passes from the compressor to the receiver, and all of those from the receiver to the air motor are thoroughly covered by some kind of non-conducting substance. Of course, if the air is to be used in a motor immediately after it is compressed, it may then be somewhat economical to compress it adiabatically; but, as a general rule, it may be stated that it is always uneconomical to compress air adiabatically.

When air is compressed by stages it is compressed partly only in one cylinder, then passed to another and partly compressed in it, and then passed on to still another cylinder and compressed partly again, and so on from one cylinder to another until the desired compression has been attained. If there be one cylinder, the machine is called a one-stage compressor; if two cylinders, a two-stage compressor; if three cylinders, a three-stage compressor, etc., etc. For each stage of the compression there is an air compression cylinder, and the machine is named according to the number of compression cylinders or stages of compression through which the air is passed before reaching the reservoir or tank in which it is stored.

It is customary to have intercoolers through which the air must pass while going from one compression cylinder to the next higher one. These intercoolers are simply vessels containing a large area of cooling surface by means of which the temperature of the air is reduced from that due to the compression in the cylinder which is left before entering the intercooler to as nearly as possible that of the surrounding air and bodies. Sometimes the cooling surface is the outside surface of a number of tubes through which cool or cold water circulates, and at other times it is the inside surface of a number of tubes which are surrounded by water. In either case, however, the action is exactly the same; heat is taken from the hot air, so that its temperature is reduced as much as possible before entering the next compression cylinder.

It is important that the cooling surface of the intercooler be large, and that the body of air be broken up and sub-divided as much as possible, in order that every particle of it may be brought in contact with the cooling surface and kept there as long as possible.

The compound or two-stage compressor is quite common, and its advantage and economy are so generally recognized that now it is considered the compressor to be used for ordinary low pressures of 80 or 100 pounds gauge pressure. For higher pressures, three and four-stage compressors are used. It should be remembered, however, that the efficiency and economy of a multiple-stage compressor depend more upon its intercoolers than anything else, and, therefore, they should be large, properly made and proportioned.

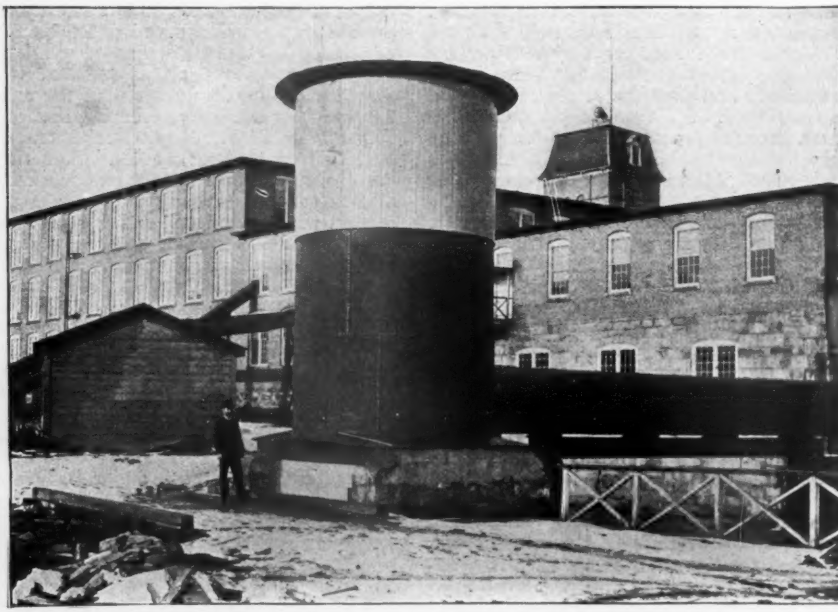
Every air compressor cylinder and every intercooler added to a compressor increase the friction which must be overcome by the driving steam cylinders or steam-engine, and, therefore, increase by a proportionate amount the work which the engine must do; and it is only when the

gross saving effected by the addition of an air compression cylinder and an intercooler is greater than the gross loss due to the increased friction and amount of machinery to be run that there is any economy in the addition of the cylinder and intercooler.

In determining this economy the interest on the first cost of the compressor must be included with the running expenses of the compressor. Just as we know that for certain pressures it is more economical to use a compound engine than a triple-expansion engine, and for other pressures it is more economical to use a single-cylinder engine than a compound engine, so it must undoubtedly be true that for some pressures it is more economical to use a single-stage compressor than a two-stage compressor; for other pressures it is more economical to use a compound compressor, and for still other pressures it is more economical to use either a three or four-stage compressor.

Exactly at what pressure a two-stage compressor is more economical than a one-stage compressor, and a three-stage more than a two-stage, and a four-stage more than a three-stage, we do not yet know, because it is only of late years that the use of compressed air has increased to such a degree as to call for very high pressures and to make manufacturers look carefully into the question of multiple-stage compressors and intercoolers. A purely theoretical investigation will show that the loss of energy due to heating the air while compressing adiabatically is, for an initial temperature of 60° Fahr. and a final gauge pressure of 110 pounds, about 38 per cent. for a single-stage compressor, 17 per cent. for a two-stage compressor, and 5 per cent. for a four-stage compressor. If the final pressure were 2,000 pounds, the loss would be about 121 per cent. for a single-stage compressor, 45 per cent. for a two-stage compressor, and 20 per cent. for a four-stage compressor.

In 1877 Mr. Frizell, of Boston, read a paper before the Franklin Institute, in which he described an ingenious method of compressing air to any desired pressure by the direct action of the water of a waterfall. This apparatus involves no ar-

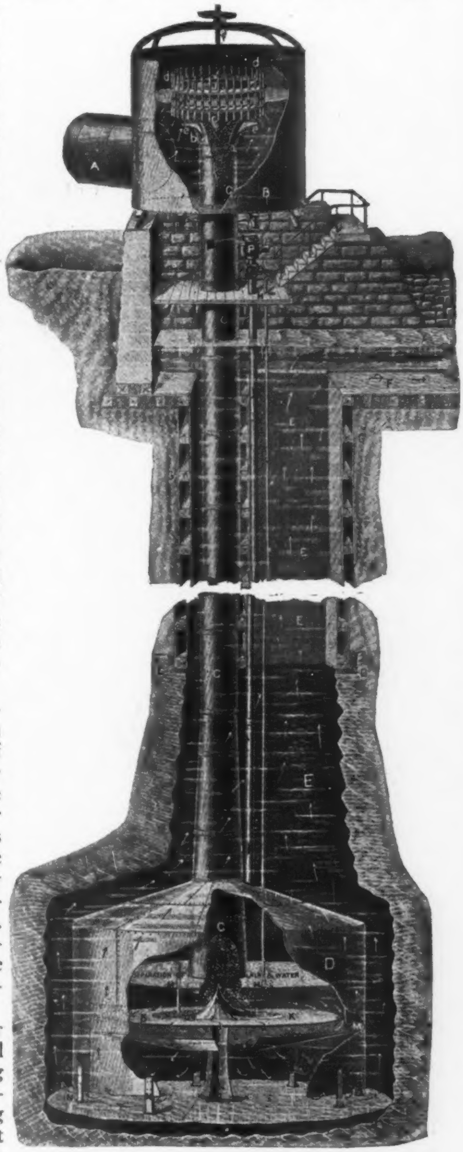


THE HYDRAULIC AIR COMPRESSOR AT THE DOMINION COTTON MILLS, MAGOG, QUEBEC.

rangement with moving parts. The water is made to pass down a large vertical tube, and carries particles, or bubbles, of air down with it. At the bottom of this tube there is a separating chamber where the air is separated from the water. The air collects in the upper part of the chamber and the water in the lower part. By means of suitable pipes the compressed air is led off to where it is to be used, and the water is led off into a waste channel or sluice. The pressure to which the air is compressed is entirely independent of the height of the waterfall, and depends only upon the length of the tube down which the water and air fall. By digging a well of the proper depth this tube may be made as long as desired; it must be approximately 2.3 feet for each pound of gauge pressure. An apparatus of this kind was installed in Canada a few years ago to supply compressed air for running a cotton mill. The superintendent of the mill wrote to me about two years after the plant had been installed and said that it gave entire satisfaction, and had been furnishing compressed air enough to run the mill ever since its installation. The compression by such an apparatus must, of course, be quite isothermal, but the air must be saturated with moisture, and would, therefore, be objectionable in many cases. On account of the depth of the well required for the compressor pipe, such an apparatus could not be used for very high presures.

After a quantity of air has been compressed so that its pressure is greater than atmospheric pressure we have a source of energy from which we can draw at any time to do various kinds of work. The numbers of places in which compresed air is used, and the purpose for which it is used, are very great and varied. Its use is constantly growing, and there are very few industries or manufacturing establishments in which it is not now employed. The use of electricity as a means of transmitting power, instead of diminishing the use of compressed air, has tended to increase it.

Compressed air has an advantage over electricity in that it is perfectly safe and harmless; there is no danger of getting shocked or of a leak setting fire to buildings or goods; and, further, the air having been compressed, it may be drawn upon at any time, without regard to whether the compressor is running or is not running, but is always ready for service as long as its pressure exceeds that of the atmosphere. A quantity of air may be com-



VERTICAL SECTION OF THE MAGOG COMPRESSOR.

pressed and then the compressor may be stopped until that air has been used; but with electricity the engine and dynamo must be kept running during the entire time when it is likely that electricity will be needed, unless a system of storage batteries be installed. These, however, are usually too expensive for the average manufacturer.

The loss due to leakage of air through the pipes by which it is transmitted from the compressor to where it is used is so small in a properly put-up system of piping that it may be neglected entirely. The main loss is probably due to the friction, but even that may be made exceedingly small by putting in pipes of proper size. Someone has said that the friction of air in the pipes does not really mean a loss because the energy used to overcome the friction is converted into heat, which raises the temperature of the air, and is given up again when the air is used to do work. In fact, however, this heat is usually lost in the surrounding air.

It is extremely difficult to get reliable data upon which to base a comparison of the cost of using electricity with that of compressed air, because of the different ways in which they are installed and used. Electric systems are always installed with great care, and are always properly installed; this is seen to by the insurance companies, and by the erectors and builders of electric machinery; but compressed air plants are usually installed in any and every way. The manufacturer buys the compressor and then puts up his line of piping as he pleases, often entailing great loss on account of small pipes and improperly made bends and joints.

Experience has shown that, in order to transmit electricity with economy, it must be transmitted at high electrical pressure and reduced at the motor; so, too, in order to transmit air with economy, it should be transmitted under high pressures. The higher the pressure the less the space which will be occupied by a quantity of air and the more efficiency can it be used. I am of the opinion that one of the reasons, and, in fact, the main reason, why compressed air at high pressures has not been experimented with more in connection with automobiles of different sizes and kinds is that there are so few plants in the country where air can be compressed at all, to say nothing of doing it economically, to pressures in the neighborhood of 1,000 to 1,500 pounds per square inch.

One pound of air compressed to 1,000 pounds per square inch, and at a temperature of about 60° Fahr., would occupy the volume of about one and one-half gallons, and if heated by a heater before passing into a motor could be made to develop a little over one horse-power for a little more than three minutes. The heat which it would be necessary to give to the air while being used would be about 150 units, or the heat which would be given off by one and one-half pounds of water cooling 100° Fahr.

The motors in which air is generally used for generating power are simply ordinary slide-valve engines in which air instead of steam is employed. When, however, the air is used expansively, as it must always be when under a high pressure, it becomes absolutely necessary to heat the air by a reheater, as it is called, just before it enters the motor. If this is not done the temperature will fall very low, and there will be a deposit of frost or ice on the pipes and cylinders of the engine.

If there is much moisture in the air, there may also be a choking up of the exhaust pipe by the ice or snow formed during the expansion. For ordinary low pressures, such as are in general use, and when the air is not expanded very much in the motor, it has been shown by experience that there is no danger of the exhaust freezing up. Of course, if the air has been deprived of its moisture during or after the compression, there is no danger at any time of a freezing up of the exhaust or a deposit of snow or ice in the cylinder of the motor.

Subaqueous Tunnels for Gas Conduits.*

At the first of the year 1899, in the distribution of its gas, the Massachusetts Pipe Line Gas Company found itself confronted by the problem of three river crossings. The one at Malden Bridge to be 54 inches, that at Charlestown Bridge 42 inches and that at River street 48 inches.

The pressure head in the tunnels, when passing gas, was liable to vary from 3 to 12 inches water column, and the problem was to keep the water out rather than the gas in.

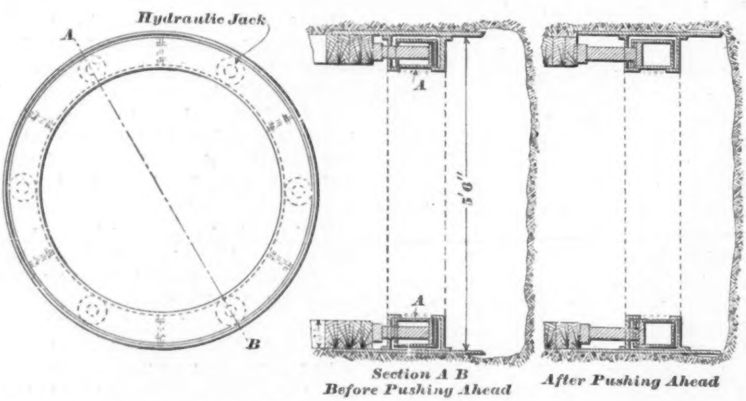
*Abstract of a paper by W. W. Cummings, Member, Boston Society of Civil Engineers, and published in the *Journal* of the Association of Engineering Societies for June, 1901.

Requirements of the State Board of Harbor and Land Commissioners gave a minimum cover of 7 feet at the Malden Bridge, and none whatever at the Charlestown Bridge or at the River Street Bridge. As a matter of fact, the legs of the siphons were placed farther apart than these requirements, in order to provide room for fenders and for working of the draw, while the least safe cover was about 8 feet of earth. It was also necessary to avoid obstructing the channel during construction.

The difference in cost between siphons and tunnels was more than balanced by the advantages afforded by the tunnel, which would be practically indestructible, independent of the changes in highway traffic and navigation, and free from possible future additions. Had the fluid to be carried been water instead of gas, the convenience undoubtedly would have outweighed the possible extra cost. As it was, the advisability of avoiding anything that might be converted into a gas pocket prevented such constructions, while the rigidity of the structure was best obtained by making it one solid piece, as by filling the space between the pipe and the lagging.

In sinking the shafts it was proposed to use ordinary sheathing until the water should be reached, and from that point to sink a steel tubular casing by means of compressed air.

The first shaft was sunk on the Everett side of the Malden Bridge, as near the abutment as the retaining wall would



SHIELD USED IN DRIVING MALDEN TUNNEL, BOSTON, MASS., PIPE LINE GAS CO.

liability to accident and need of repairs, and it was at Malden Bridge and at the Charlestown Bridge about April 1, 1898, that the Malden Bridge Tunnel was started.

Both the Malden and Charlestown tunnels were completed about December 1, 1899.

Three methods were suggested in the design of the tunnels. In all of these the tubular casing by wooden lagging (a method originated by the contractor, Mr. Charles Haskin, and described later) was considered.

One plan was to line the lagging with brick masonry laid under compressed air, and to lay the pipe or pipes on blocking, free and open to inspection, repair and allow. After going about 6 feet, the steel caisson was erected and sunk in the ordinary wav, paving stones being placed on the shelf and the excavation carried on under the cutting edge. The casing was kept plumb by varying the excavation and also by such guides as might be used at the top. The caisson was extended by removing the air lock and inserting a 10-foot section, caulking the flanged joints when necessary.

This shaft was 46 feet deep 43 feet below high water, at which times, of course, the air pressure was about 23 pounds.

The steel casing was made of ⅜-inch boiler plates riveted to a 3-inch angle iron, which, with the corresponding angle iron of the next section, formed a flanged joint

that was made up with red lead and caulked where necessary. The inner diameter of the tubing was 7 feet and the length of a section was generally 10 feet, each section weighing about 4,000 pounds.

The cutting edge was made on the first section by placing a wide flange 2 feet back from the bottom and staying it with brackets. On this shef the paving stones were placed, to balance the upward pressure of the air and to furnish a downward thrust at the cutting edge. Stones, piles, sunken timber, etc., were broken up and taken out through the lock.

When material sufficiently compact to prevent the escape of the air was reached, the sinking of the caisson was stopped, and the lagging was carried down the shelf.

This lagging consisted of circular segments 6 inches wide, sawn from 2-inch plank and having an outer diameter of 7 feet. There were eight of these segments to a ring, and they were placed by spiking to the previous work with 7-inch spikes, each ring breaking joints with the previous one. This construction, which was the same as that used in the tunnel proper, was found to be exceedingly rigid.

A few feet above the point where the tunnel was to be started, the tubular form was changed and the "goose neck" was started. This consisted in constantly lengthening that diameter of the shaft parallel to the axis of the tunnel, on the side from which it was to start, until room enough was obtained to turn a 54-inch pipe, 8 feet long, into the tunnel. In this goose neck the sides were necessarily flat, but, being surrounded by stiff clay at this shaft, they showed no sign of weakness. At the Charlestown tunnel, however, the material was sandy and the side came in.

The shaft was driven 6 feet below what was to be the bottom of the tunnel, and 4 feet of concrete were put in as a foundation of the pipe that was to make the leg of the siphon.

The shaft on the Boston side was then sunk in the same way, and the tunnel started from that end.

In driving the tunnel a shield was used similar to the Greathead design, as shown in the first illustration. The excavation was carried about two feet ahead of the shield in good digging, and the latter was pressed forward by the hydraulic jacks *a a* bearing directly against the lagging. This served a double purpose, pushing the shield forward and closing up the joints in the lagging, although, as the lumber was thoroughly dry when placed, it was found that the swelling of the wood made very tight work. The lagging was then given a wash of cement after it was in place, and such leaks as later developed were caulked with wooden wedges and yarn, and by feeding dry cement into the holes, the escaping air under pressure carried the cement with it.

North of the draw the tunnel ran beneath an ice guard, and the bottom of the piles had to be cut off in the heading. This occasioned no great hardships while the driving was in clay, but about three-quarters of the way across the river a streak of silt and sand was struck, which, being only 7 feet thick between the top of the tunnel and the bottom of the river, followed the piles into the heading and stopped the work.

Poling planks were driven ahead, and cut so that the ends could be worked back on the cutting edge of the shield. Gunny sacks, filled with horse manure, sawdust, etc., were thrust into the cavities, and, as soon as the holes were plugged, they were quickly plastered with clay. The material ahead was then excavated and the shield pushed forward. The surrounding material was so soft and unstable that the lateral movement of the shield was scarcely controllable, the whole structure moving toward the side that caved in.

As a whole, however, after the soft material was passed and the transit line extended, the headings met within 0.42 inch. The tunnel was allowed to fill with water and to remain filled for a few days, to give the woodwork a chance to swell and to permit the silt to pack about the lagging.

To a great extent this closed the remaining leaks, so that a No. 5 3-inch pulsometer easily kept the water down after the air pressure was removed. After pumping the tunnel out, a cross-section was taken, and this, compared with one

taken before, showed that the tunnel had flattened about ½ inch, thus proving that the lagging would not be permanent of itself.

In giving the line of the tunnel the distance between the shafts was triangulated and the direction transferred to the tunnel by means of two wires which passed through holes tapped in the air lock. This gave a base line about 4 feet long, which was produced into the heading by means of nails in the roof of the tunnel.

The Charlestown Tunnel was commenced as soon as the air lock could be spared from the Malden Tunnel.

The shafts were sunk in midstream from temporary platforms, and did not differ materially from those of the Malden Tunnel.

For convenience in handling the water in working from both shafts at once, the summit was placed between the shafts. This tunnel was driven without a shield, under an air pressure of 28 pounds, the clay being stiff enough to maintain the heading except in one part where gravel was encountered in the roof. Here poling boards, horse manure, etc., were used, as in the Malden Tunnel, except that the poling planks were worked back on the lagging when cut off, instead of the shield as in that tunnel.

In the River Street Tunnel the Brighton shaft was sunk 90 feet, and the Cambridge shaft 60 feet. It was commenced by sinking the Cambridge shaft without the steel caisson and running the tunnel in 80 feet without compressed air. At that point the clay changed to a vein of sand, and the heading came in, filling the tunnel for 40 feet and destroying the cross-section.

The Brighton shaft was then sunk to a depth of 90 feet before enough clay was found to turn a goose neck. The old shield could not be used, because it was not large enough, and on account of the scarcity of steel it would have taken too long to procure a new one. As matters turned out it would have been better to wait for a shield, but the borings seemed propitious and a heading was started.

The enormous head made 36 pounds air pressure necessary and also greatly increased the leakage, as much as 1,000,000 gallons daily being pumped by three Knowles 5-inch pumps.

After going a short way, the roof material changed to sand and continued so to the completion of the tunnel. "Cave-ins" and "breakdowns" were of everyday occurrence, and every incentive was used to keep the men at work.

Negroes were worked in one heading and white men in the other, pitted against each other as to courage and record; extra time was given and shifts shortened, but under the heavy pressure, with the temperature at 105° and the slow laborious methods necessary in the uncertain heading, progress was very slow, and it was only the indomitable courage of the contractor that carried the work to a successful completion.

The general method of procedure was to drive poling planks ahead, a couple of feet of the sand was excavated, the surface was smeared with clay to hold the air and a bulkhead was thrown across. The clay bottom was then excavated, the lagging brought forward and a new start made in the sand. Progress was from one to three feet a shift in each heading.

The results in alignment were such that it was necessary to make two offsets of 2 feet each, to keep the transit line in the tunnel. Nevertheless the closing error was less than 0.05 foot.

The lagging was lathed and plastered with cement, and about 6 inches of concrete was placed in the bottom while the air pressure was still on. The air lock was then removed, and six 12-foot lengths of 48-inch pipe, with the drip, were lowered in the Cambridge shaft, the lock was replaced, and these were hauled through to the Brighton shaft, where two lengths were supported in the shaft while the drip was set and concreted.

These two pipes were then set and concreted, and a 6-inch drain pipe was laid in the concrete connecting the tunnel with that part of the shaft above the pipe. The five other lengths were laid from the drip in the tunnel, and the 6-inch drain pipe was continued beneath them. Owing to the rapid rise in the tunnel, this had the effect of materially reducing the head, and when six more pipes were laid in the tunnel in the same way, an attempt was made to proceed without the air pressure.

There was too much leakage, however, for the three pumps in the Brighton shaft, and there was no room for more pumps. Moreover the pumps or their connections were continually breaking down and it was decided to lay the pipe under pressure.

The general methods were about the same as those used in the Charlestown Tunnel, except the plastering of the lagging, the laying of the 6-inch drain and the handling of the concrete. The concrete was mixed on top, lowered through the air lock in canvas bags, twelve or sixteen at a trip, and wheeled to the point of laying in three or four barrows, four bags filling one barrow. As each man dumped his load, he wheeled his empty barrow into the pipe to make room for the man behind him.

The proportions of the concrete were: 1 cement, 2½ sand, 5 broken stone. In two hours this set sufficiently to permit walking over.

As a rule three 8-hour shifts of 9 men each were employed in driving the tunnel, and progress was about three feet each shift.

In laying and concreting the pipe, there were two 11-hour shifts of from 11 to 13 men, averaging one pipe each shift. There were eight batches of concrete to each length of pipe. The men received 23 cents an hour when working under pressure.

The plant included 3 locomotive boilers, 2 upright boilers, one 5-drill and one 4-drill unjacketed compressor, and one 14-inch and one 10-inch jacketed compressor, one 6-inch and three 5-inch steam pumps at 75 pounds and 110 pounds steam pres-

INTERIOR OF FINISHED CHARLESTOWN TUNNEL, BOSTON, MASS.

sure, respectively, three 3-inch pulsometers and two 4-inch ejectors.

As in the other tunnels, all joints on the inside of the pipe were filled flush with cement.

The cost of the Malden Tunnel was $35.34 per lineal foot for driving the tunnel, $15.50 per lineal foot for the pipe and $4.80 per lineal foot for laying the pipe and grouting, or $55.64 per lineal foot complete.

On the Charlestown tunnel the cost was as follows: Driving and fenders, $87.45 per foot; pipe, $4.35 per foot; laying, $9.60 per foot; total cost, $101.40 per foot.

The quantities were as follows: Concrete, 420 cubic yards; 42-inch pipe, 85 tons; cement, 200 barrels, at $2.35 to $2.75; sand, 200 tons, at 70 cents; stone, 600 tons, at $1.

At River Street Tunnel the cost was as follows: Driving, $48.84 per foot; laying, $45.45 per foot; pipe, $5.36 per foot; total cost, $99.65 per foot.

The quantities were: Concrete, 560 yards; stone, 1303 tons, at $1.10; sand, 97 loads, at $1.60; 48-inch pipe, 169 tons; cement, 859 barrels, at $2.35 to $2.75.

Cost of labor on concrete in tunnel about $5 per cubic yard. Cost complete of concrete in tunnel about $9 per cubic yard.

The choice between driving a tunnel and sinking a siphon is naturally governed by the location. Where the requirements of depth and width are great and the obstruction to navigation while sinking the siphon is serious, especially in the case of a double draw, the tunnel is cheapest in any ground. The same may be true of a single draw in good ground. Where the pipe, for any cause, cannot be supported by the bridge, and the approaches are exposed to ice and heavy shipping (a condition requiring strong fenders) and where the earth is propitious, it may be cheaper to tunnel the entire river, as was done at Malden Bridge.

Where the channel may be obstructed by temporary piling, and where the requirements as to preserving the channel are not burdensome, a siphon is undoubtedly the cheapest, as in the crossing of the Island End River, now under way. It is needless to say that a tunnel is *always the best.*

In these tunnels it has been demonstrated that in good clay, and in good clay only, a tunnel can be advantageously driven without a shield under compressed air; that the segmental lagging, as used by Mr. Haskin, is an easy, economical and stable method; that breaks, even in bad ground, are neither necessarily dangerous nor prohibitively difficult; that a large tunnel, with concrete between the pipe and the lagging, although more costly than a smaller tunnel grouted, makes much tighter work; that turned and bored joints are a delusion and a snare; that it pays to point up the joints on the inside of the pipe with cement; that cement joints give the best results, and are the cheapest and most convenient; that lathing and plastering the lagging with cement, while under compressed air, is an advantage.

Mr. G. H. Finn is the general manager and Mr. L. J. Hirt was the chief engineer of the Massachusetts Pipe Line Company. W. E. Silsbee had immediate charge of the Malden and Charlestown Tunnels, while E. C. Hayden had immediate charge of the River Street Tunnel.

In the discussion which followed Mr. Howard A. Carson said some allusion had been made to the East Boston Tunnel. I hope most of the members will visit this tunnel within a few days. The work has now progressed, by the shield, something like 240 feet. The work is temporarily arrested, to put in the air locks. Before the compressed air is used will be an excellent time for the members to view the whole situation. As you will learn all about it then, I will say now but a word for those who cannot go.

The general method employed there is almost precisely the same as that which was used on the subway tunnel on Tremont Street. There are two drifts about 8 feet square, made and timbered by an ordinary tunneling process. These drifts are about 30 feet apart horizontally, outside to outside. In each of these drifts one of the side walls of the tunnel is built. The shield of the tunnel is later moved along, running on top of and resting on these side walls. The arch of the tunnel is built under the tail end of the shield, and, of course, joins with the side walls just mentioned. The invert is put in later. The hydraulic jacks, which push the shield along, react against cast-iron rods imbedded in the masonry of the arch, the same as on Tremont Street.

Mr. Robert A. Shailer said: In the paper

just read considerable stress was laid upon the use of compressed air for the purpose of keeping out water, and the thought occurred to me that possibly you are not all familiar with the use of compressed air for the purpose of keeping clay from flowing or swelling, as it is usually termed.

We have been working for a number of years at Cleveland, Ohio, constructing a tunnel 9 feet inside diameter, with 12-inch brick walls and 26,000 feet long. The 22,000 feet already completed have been constructed through a very soft, swelling clay, in fact, a material which it would be almost impossible to handle without compressed air. It contains no water to speak of, and if any of you were to go into the tunnel under our usual pressure of 28 to 30 pounds of air, the clay would seem practically dry and quite stiff and hard, and it would be difficult to realize what it would be without the air pressure.

In sinking shaft No. 2, which is composed of cast-iron cylinders extending from above the surface of Lake Erie down nearly to the top of the arch, which is at about grade minus 94, and then underpinned with brick, we had occasion to take the air pressure off, and where square openings like windows were left for the purpose of breaking out into the drifts, I have seen clay flow in through said openings and drop off in large chunks, while with the air pressure the clay appeared still and stable. Last fall, when one of the air locks in the tunnel got to leaking, so that the pressure was almost entirely lost, the clay flowed into the completed tunnel so as to nearly fill it up solid for some twenty feet.

Mr. Carson has just spoken of our being about to put on the air pressure in the East Boston Tunnel. We anticipate no trouble or danger from water in carrying on this work, but we do expect to have swelling clay, and it is to hold the clay that we are installing the pneumatic plant.

There is another use of air pressure in which we have had some experience, and that is for the dilution of explosive or marsh gas, as it comes into the tunnel.

At Cleveland the whole ground is saturated with this gas, and chemical analysis shows that even with great care we have from ¾ to 1½ per cent. of this gas at all times in the air which the men breathe. If our pressure goes down, the percentage of gas becomes greater, so that we are reasonably sure that the use of compressed air tends to keep the gas out. The mixture of 5 or 6 per cent. of gas is exceedingly explosive, while a mixture of 9 to 10 per cent. is not. This may seem paradoxical, but it is true. What I have always feared is that, as the gas must flow into the tunnel practically pure, there must be, somewhere between that and its dilution down to 1½ per cent., a point at which the mixture is dangerous. We therefore watch our electric wire connections, and take all the precaution we can and carry our inlet pipe straight up to the heading, so as to dilute the gas there.

Compressed air has been used to retard the flow of water into tunnels where the head was so great that sufficient pressure could not be maintained to keep the water out entirely. Under these conditions the work of necessity must be carried on very slowly and at great expense.

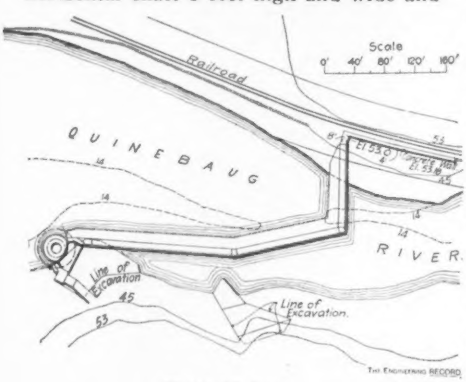
The Norwich Hydraulic Compressed Air Plant.

On the Quinebaug River at Taftville, Conn., an interesting hydraulic compressed air plant is now nearing completion, which has attracted considerable attention from New England engineers. It is the property of the Continental Compressed Air Power Company, of which Mr. John A. Inslee is manager, and its purpose is to furnish compressed air through 3 miles of 16-inch plain cast-iron pipe to power users in Norwich. This pipe, it may be said in passing, will have double stuffing-box joints with soft rubber bands.

The conditions at the site of the plant gave the hydraulic works, designed by Mr. J. Herbert Shedd, of Providence, an unusual arrangement. The dam has a Z-shaped plan made necessary by the narrowness of the gorge and the proximity of a railway. It is built of concrete, in three sections. The first is approximately 120 feet long and inclined slightly upstream, meeting the second at an angle of about 110 degrees. This second section is about 140 feet long and inclined downstream at a sharp angle with the opposite bank of the river. The third section is 200 feet long and is still more sharply inclined to the bank. This extreme length was deemed necessary in order to obtain a sufficient rollway, for the river is only 240 feet wide at this place. The dam is 7 feet wide on top and about 18 feet high on an average. The upstream face is

nearly vertical, while the downstream face has a batter of 1:6. The top is fitted with hinged flashboards of a new type.

The dam terminates in a forebay about 40 feet wide, with abutments rising 12 feet above the top of the dam. This forebay ends in a nearly cylindrical head tank of sheet iron, approximately 24 feet in diameter and 18 feet in height. Below this head tank is a cylindrical shaft sunk into the rock below the bed of the river for a depth of 208 feet, 24 feet in diameter for the first 138 feet of its depth, then gradually enlarging into a chamber 52 feet in diameter with vertical sides 20 feet in height. In this shaft is a downflow pipe of an average diameter of 12 feet 8¾ inches, of ⅜-inch steel plates, terminating in a cylindrical tank 47 feet in diameter with vertical sides 16 feet in height, covered by a conical roof joining the downflow pipe. Leading out from this large cylindrical chamber at the bottom is a horizontal shaft 8 feet high and wide and



PLAN OF DAM.

100 feet in length, as a storage chamber. This is screened off from the main shaft by a curtain wall through which projects a 24-inch wrought iron pipe leading from the top of this horizontal shaft to the upper end of the conical roof of the cylindrical chamber before described, which forms the air chamber. Also leading from the upper part of this conical roof is a 16-inch air supply pipe leading to the surface.

The compressor, with all of its operative parts, was designed by and erected under the charge of Messrs. Webber & Smith, of Boston.

The average head of water on this compressor is 18½ feet and the plant is expected to give 1365 horse-power of compressed air at a pressure of 85 pounds per square inch, and was designed and calculated on an average flow of 680 cubic feet of water per second. This compressor is expected to give an efficiency of 85 per cent., based on the results of Mr. J. P. Frizell's experiments at the Falls of St. Anthony on the Mississippi River, who obtained from 40 to 51 per cent. on a small compressor with a shaft 29 feet in depth, and a downflow pipe of 450 square inches, and estimated that a shaft 10 feet in diameter and a depth of 120 feet, with a fall of water of 15 feet, would give 76 per cent. of efficiency, and that with a head of 30 feet and a fall of 230 feet, with a shaft 10 feet in diameter, an efficiency of 81 per cent. would be realized. These expectations have been carried out, in that the plant at Magog, with a head of water of 22 feet, and a downflow pipe 44 inches in diameter to a depth of 128 feet, has given an efficiency of 71 per cent.

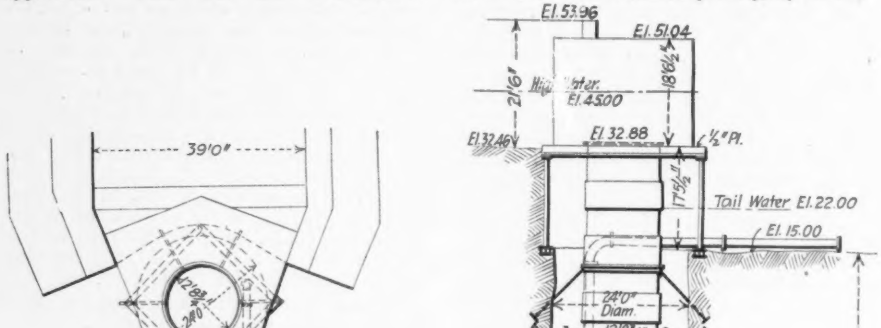
An article describing these tests at Magog was printed in *The Engineering Record* on June 1, 1901. It was based on a paper presented to the American Society of Mechanical Engineers by Mr. William O. Webber, and from another paper by the same author, read before the Boston Society of Civil Engineers last November and printed in the *Journal* of the Association of Engineering Societies, the following notes on compressors of this type have been condensed.

Air compressed by the ordinary mechanical methods contains at least the same amount of moisture as the surrounding atmosphere from which it was compressed; and, in parting with the heat necessarily contributed to the air by the mechanical compression, it is inclined to absorb more moisture. Air compressed directly by falling water is kept at the same temperature as this water. It is compressed isothermally, and the consequent expansion, when used in motors, produces an almost truly adiabatic expansion line. Tests, however, have shown that air compressed in this manner contains only one-sixth of the moisture originally in the surrounding atmosphere from which it is compressed. Incidentally there is no loss of power in parting with any heat, and there is a practical result which is of more importance—the hydraulically compressed air can be expanded down to a temperature much below the freezing point; while atmospheric air, with the usual amount of moisture, mechanically

compressed, cannot be used at all, owing to the freezing up of the exhaust passages of the motor in which the attempt to use it is being made.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydraulic air compressor which operated as an entrainment apparatus. This was the well-known made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes or tuyeres to the forge, the water being allowed to escape from the lower edge of the bag.

Siemens invented an apparatus on the principle of the steam injector, but the use of this was confined principally to the

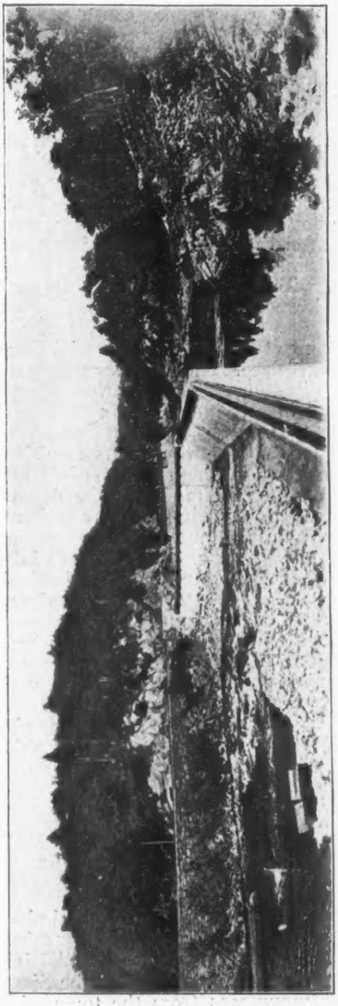


DETAILS OF SHAFT, CONTINENTAL COMPRESSED AIR POWER COMPANY.

water bellows or trompe of the Catalan forges. This apparatus, briefly described, consisted of a bamboo pole, disposed at a slight inclination from the perpendicular, into the upper end of which a stream of water was led, entraining air with it in its downward passage. The lower end of this bamboo pole was introduced into a bag production of a vacuum. It is used to operate the pneumatic dispatch tubes in London. It has also been used for blast purposes in Siemens' furnaces and in sugar works.

Another quite ingenious device, shown in a patent granted to W. L. Horne, consists of two flat horizontal plates inclosing

between them an air space from which a pipe leads to the atmosphere. The upper plate is perforated with conical holes, the smaller end of each hole being adjacent to in the lower plate, with the smaller end of the aperture next the air-space, the lower and larger part of the conical openings being prolonged by tubes. The upper plate



VIEW OF FACE OF QUINEBAUG RIVER DAM.

VIEW OF UPPER SIDE OF QUINEBAUG RIVER DAM.

the air space between the two plates. Directly opposite the apertures of the upper plate are corresponding conical apertures is kept under a head of water, and the water jet, passing across the thin air space referred to, draws in the air through

the large air pipe leading from the atmosphere and compresses it through the smaller orifices.

One of the first inventions carrying out the idea of the old trompe was made by Mr. J. P. Frizell, of Boston. His invention made use of an inverted siphon having a considerable horizontal run between the two legs. A stream of water was led into the upper end of the longer leg and at the top of the horizontal run between the two legs of the siphon was provided an enlarged chamber in which the air separated from the water. The water was then led off from the lower part of this air chamber and passed off through the short leg of the siphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter leg of the siphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

Mr. Frizell made two working models of this type of apparatus. In the first the legs of the siphon were 3 inches in diameter, the head of water being 25 inches, and an efficiency of 26½ per cent. was obtained. The second model has already been mentioned.

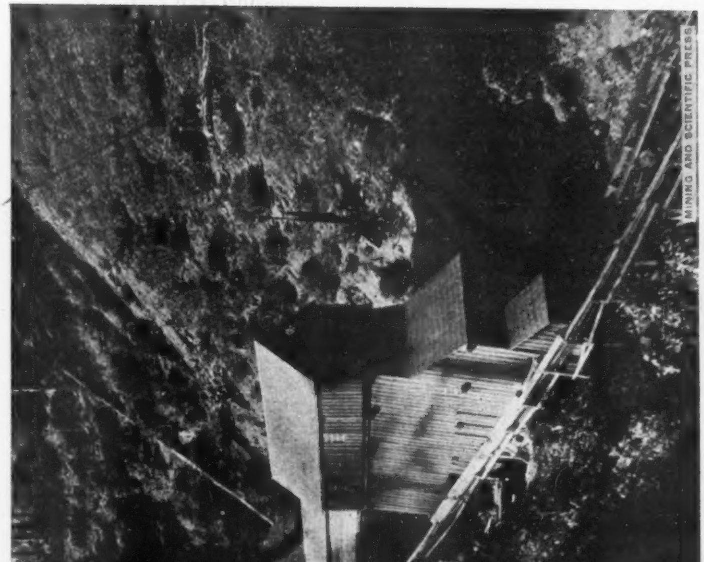
Another air compressor, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahnass in 1885, and consisted of a siphon carrying water from an upper to a lower reservoir, the lower end of the siphon being projected through an inverted vessel placed nearly at the bottom of the second reservoir. Just beyond the bend of the siphon, and in line with the vertical axis of its longer leg, an air pipe projected into the descending leg of the siphon, thus entraining the air with the descending column, which carried it down into the inverted chamber, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it. Another device patented by Thomas Arthur in 1888 dispensed with the siphon and had the air pipe rising through the vertical pipe down which the water passed to the chamber at the bottom of the shaft.

A number of patents on apparatus of this type were issued to Charles H. Taylor in 1895. His inventions consisted principally of a down-flow passage having an enlarged chamber at the bottom and an enlarged tank at the top. A series of small air pipes projected into the mouth of the water inlet from the large chamber at the upper end of the vertically descending passage, so as to cause a number of small jets of air to be entrained by the water, Taylor seemingly having been the first to introduce the plan of dividing the air inlets into a multiplicity of smaller apertures evenly distributed over the area of the water inlet. Taylor at first seems to have attempted to utilize centrifugal action in causing the separation of the air from the water in the larger chamber at the bottom of the compressed column; but he afterward abandoned this scheme and used, instead, deflector plates in combination with a gradually enlarging section of the lower end of the down-flow column, in order to decrease the velocity of the air and water and cause partial separation to take place. The deflector plates changed the direction of flow of the water. This was evidently intended to facilitate the escape of the air.

The latter improvements on this device have been in the method of introducing the air into the mouth of the downwardly flowing water column, so as to insure the largest proportion of air being taken down with the water, and in methods of decreasing the velocity of the combined air and water at the bottom of the descending column, causing the water to part more readily with the air, the water then passing out at the bottom of the enlarged chamber into an ascending shaft, maintaining upon the air a pressure due to the height of water in the uptake, the air being led off from the top of the enlarged chamber by means of a pipe.—*The Engineering Record.*

Compressed Air Traction Plant, Red Point Mine, Placer County, Cal.

The Red Point mine is a gold placer situated in Placer County, Cal., on what is locally known as the Forest Hill Divide, 15 miles toward the summit of the Sierra Nevada mountains from the town of Forest Hill. It adjoins the Hidden Treasure mine and, like it, is exploited as a drift mine. Both are sections of Neocene river channels which were obliterated as such by filling to depths of a thousand feet or



PLANT OF RED POINT MINE, PLACER COUNTY, CAL.

more by volcanics. Subsequent erosion of new stream channels, replacing those buried, has cut the country surface in deep canyon lines across and alongside of the old channel beds until the latter were left part of existing mountain summits. The method of drift mining developed from the physical position of the gold-bearing placer in the heart of the mountain consists in driving tunnels through the solid rock rims of the side of the mountain, so that they enter the unconsolidated gold-bearing gravel beds of the old channel beneath the covering of volcanics. The tunnel then furnishes a gravity drainage outlet for large flows of underground water collected in and following the old stream beds, and the gold-bearing gravel is attacked and removed much in the manner of the mining of coal. It is the winning of a horizontal-lying deposit of ore as contrasted with the winning of a proximately vertical-lying deposit.

The Red Point mine is notable from the mode in which its discovery was made. Unlike most of the California placers, the locus of which was discovered in the early mining days, even if not then mined, the existence of this particular gold-bearing placer is a comparatively recent development. J. B. Hobson, at that time (1885) of Placer County, but now manager of the Cariboo Con. Hy. mine, at Bullion, B. C., deductively from the geology becoming satisfied that the gold-bearing old river channel traversed the ground, now the Red Point, located and brought the area and interested French capital in its exploration. Ross E. Browne, M. E., of San Francisco, then made an elaborate survey of the ground and adjoining mines that were being operated and made a proximate location of the line and elevation of the old buried channel, and what is now known as the Red Point tunnel was projected and run to develop the channel. The method of location employed—a practical application of topographic and geological surveys—was novel then. Very little of that class of work had been done then, and none on so large a scale, or for the development of a channel that was buried throughout its whole extent for many miles and only doubtfully identified in the underground workings several miles apart. The tunnel projected by Mr. Browne proved successful, striking only 15 feet below the bed of the channel at 2,000 feet, the projected distance having been 2,400 feet. The close determination of the actual geological facts in advance, deductively in this instance, was a brilliant demonstration of a theory applied. Descriptions in detail of this work appear in the VIII Annual Report of the State Mineralogist of California, page 749.

The Red Point mine has been operated continuously since 1887 and has been continuously a profit-earning mine. The main tunnel, following the turns of the old channel, has been extended until the face of the working is now about 17,500 feet from the entrance to the tunnel, nearly 3½ miles. In this distance, with up-hill gradients varying from 1 per cent. to 3 per cent., the total rise is 240 feet. The fast-increasing distance of haulage some years since compelled a change from the use of horses. The loaded cars run out of the mine by gravity under the brake, but the in-haulage with the grade and distance to be overcome was the difficulty. The installation made and now in operation was designed by H. C. Behr, mechanical engineer, then of San Francisco, but now of Cape Town, South Africa.

The choice lying between electric traction and compressed air, the economic conditions made the decision in favor of the latter. The workings in the channel were more or less uneven in height, dependent on the full depth of the gravel, which was all mined out. The roof consists of a hard, compact volcanic cement. For mining the gravel it was not necessary to remove this or the bedrock on which the gravel rests. The latter is cut down in the tunnel to provide a more even track floor, a better water drain channel and to give sufficient height for traction. The roof of cement is, however, kept unbroken.

The installation of electric traction would have required a very large expense in cutting the roof, and extra expense in wiring the trolley, owing to turns and irregularities of the tunnel. There is practically no tunnel timbering to which the trolley insulators could be attached. Since the compressed air installation for traction was made in the Red Point mine, an electric traction installation has been made in the Hidden Treasure mine, adjoining. In this installation the difference of initial cost was in favor of the electric installation. The tunnel is everywhere timbered and did not require any additional cost of cutting to provide for putting in trolley

60-TON COMPRESSED AIR MINE LOCOMOTIVE, RED POINT MINE, PLACER COUNTY, CAL.

wires. In both cases the operating prime mover was the water flowing out through the mine openings. The two different systems of traction installed in the two adjoining and similar mines, each in its particular place the most economic for that place, shows how impossible it is for broad generalizations to be made as to comparative economy between electric and compressed air systems of traction. Each mine is a problem by itself, demanding economic solution, not from generalizations from practice elsewhere, but from the special conditions as they are found to be in the particular mine. In the Red Point mine the mine waters are the prime mover for power for all purposes for which power is used. The water is first caught up and turned into a pipe well up toward the inner face of the upstream workings. This pipe delivers the water under the head of the tunnel fall to a 36-inch Pelton wheel, located in the tunnel about one-half mile from the entrance. This water drives a No. 4 Baker blower, giving its positive pressure as an addition to the air pressure in an 11-inch pipe from a blower outside of the tunnel. From this Pelton wheel the water flows through the tunnel to the entrance, where it is divided. The total quantity of flow is 70 cubic feet a minute. Of this, about 30 cubic feet is conducted to the storage tank, to be used for washing the gravel. Forty cubic feet is turned into a pipe leading down the mountain slope and is used under 103 feet head on a 36-inch Pelton wheel, driving a No. 4½ Baker blower. These two blowers and the single 11-inch pipe line, conducting the air to the workings in the face, ventilate the mine.

After use driving the blower the water passes through a head box into another pressure pipe line. Under several hundred feet pressure the water operates a 5-foot Pelton wheel, driving a three-phase Simmons air compressor, which compresses 120 cubic feet of free air per minute to 800 pounds to the square inch pressure. From the receiver a strong 2-inch pipe conducts the air 3,500 feet to the tunnel entrance and 11,500 feet farther into the tunnel. In addition to providing several convenient charging stations, the long pipe acts as a receiver, giving added storage capacity.

A six-ton air locomotive, with a storage capacity of 60 cubic feet of compressed air, takes the air from the charging stations at 700 pounds pressure. From the large receiver on the locomotive the air passes through a Foster reducing valve and is reduced to 200 pounds pressure. It is then reheated to 300° F. and, passing into cylinders, is used in all respects as if it were steam.

The locomotive takes sixteen to eighteen cars into the mine at a trip, at a speed of 9 miles an hour. The engine is charged before starting into the tunnel and takes a second charge in the tunnel. A single charging will run it up the tunnel grade with the train of empties for 2 miles. Coming out, the down grade of the track takes the loaded train out of the tunnel by gravity. The track consists of thirty-pound rail and ties are placed 1 foot apart.

The mine employs sixty-five men. The output of gold has been quite uniform through the entire period of operation. Variations in width of the channel and quantity of gravel have been found to be compensated to some extent by opposite changes in the quantity of gold content. With the adjoining Hidden Treasure mine, the Red Point mine is a typical drift mine, representing in its operation all the perfection and detail and economy of cost that experience in this kind of mining has suggested.—*Mining and Scientific Press.*

The New Compressed Air Motors for City Traction.

As the result of extensive and, in the main successful, experience with compressed air motors in New York City and in Chicago, the Compressed Air Company has recently been making a number of very interesting modifications and improvements in its motors for street work. In designing those early motors the steam locomotive was taken as a model and the wearing surfaces were proportioned accordingly. It was found, however, in service these proportions were inadequate. The conditions under which the motors must work were severe and there is more dust and dirt to wear the moving parts, and especially lubricated parts.

At the same time that the wearing surfaces have been increased the power of the machine has been augmented. In the earlier motors, for street service, the diameter

of the cylinders is 6½ in., with a stroke of 12 in. The diameter has now been increased to 8 in. with the same stroke, but with driving wheels 27½ in. in diameter instead of 26 in. As the mean effective pressure has been kept the same, the increase of tractive power is as 19.5 to 28.

In order to have the same radius of action as before it has been necessary to increase the storage capacity in proportion. The new cars, which are being delivered to the Rome City Railway, of Rome, N. Y., have a storage capacity of 79 cu. ft., instead of 56 cu. ft. as before. This increase of storage capacity is almost in exact proportion to the increase of tractive power. Judging from the performances of the cars of the Rome City Railway, the storage gives from 12 to 14 miles at a speed of about 13 miles an hour, including stops.

With the increase of power in the cylinders stronger attachments to the frames became necessary. The number of bolts by which the cylinders are held is increased and wedges are introduced after the fashion of the locomotive fastenings, and the flanges are made stronger and heavier.

The axles have been increased from a diameter of 3½ in. to 4 in. Cast steel has been substituted for cast iron in the driving wheels centers, and the thickness of the tires has been increased from 1¼ in. to 2 in. The crank pins have been enlarged and the eccentric rods have been made heavier to do away with the springing that had caused some disturbance in the valve motion. The bearings on the eccentrics themselves have also been widened to obviate heating that formerly gave some annoyance.

The valve motion has been overhauled and practically redesigned. In the earlier valve motions the main valve was driven by a link motion with two eccentrics, while the riding cut-off valve was driven by a separate eccentric and was made to vary the admission under the control of the motorman. It was found in practice that this was an uncalled for refinement. The training of the men on the front platform of these cars was such that they failed to appreciate the value of the variable cut-off with the result that it was entirely neglected and the engine was worked through the run just as it was started. The third eccentric has been abandoned, and the riding cut-off valve is driven from the crosshead through a rocker. This has greatly simplified the valve motion, has lessened the number of parts and connections and made it possible to secure larger bearings. With this new arrangement the riding valve is made to give a constant cut-off at one-sixth the stroke. This is maintained at all times, both at the start and on the run. In order that the start may be made promptly and with a quick acceleration, a by-pass valve is used whereby the air is admitted beneath the main valve and through it to the cylinder for about seven-eighths stroke. This admission is controlled by a separate valve and handle on the platform. It is closed as soon as the car is in motion. The reverse lever is, therefore, always held in the extreme limit of its throw and an economical point of cut-off is insured without depend-

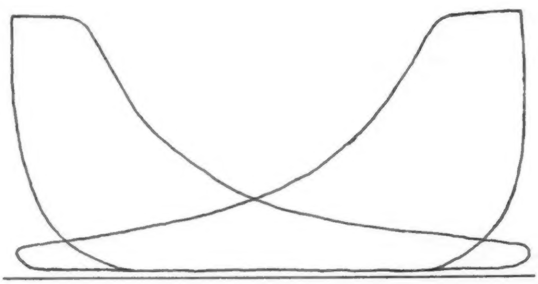


FIG. I.—INDICATOR CARD FROM COMPRESSED AIR MOTOR.

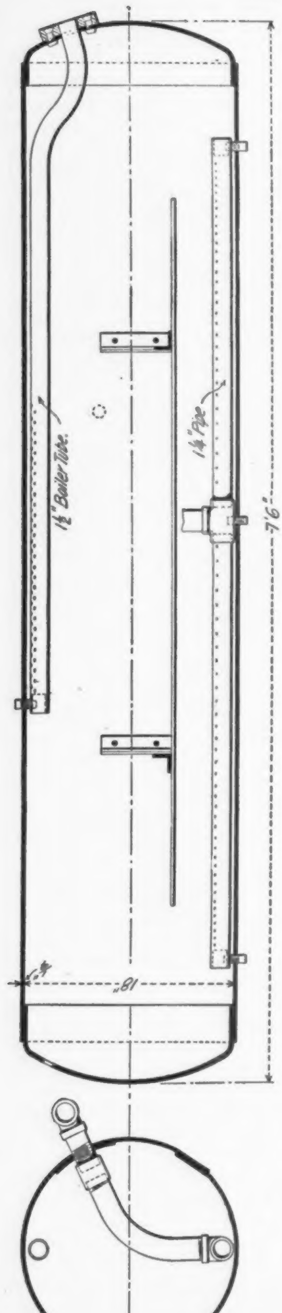


FIG. 2.—HEATER FOR COMPRESSED AIR MOTOR CAR—APRIL, 1900.

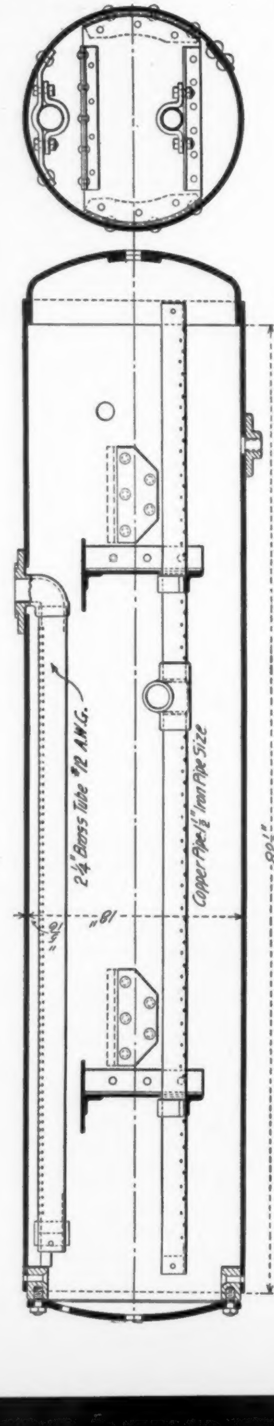


FIG. 3.—HEATER FOR COMPRESSED AIR MOTOR CAR—THE LATEST DESIGN.

ence being placed upon the judgment of an untrained man.

Indicator cards taken from the new cars show a remarkable fineness of lines and a distribution of the various elements of admission, expansion, exhaust and compression that are models of their kind. One of these cards is reproduced, Fig. 1.

The reversing connections have also been changed. In the earlier types of motors the reach rod was designed on the locomotive plan and gave annoyance by vibration under the motion of the car. It not only disturbed the proper distribution of the air, but its rattling added noise. This rod has been done away with and a tension rod substituted therefor. This rod runs out in each direction to the end of the car, where it is attached to a tiller cable running over a sheave and fastened to the reverse lever. The whole is kept taut by turn-buckles and, as it works under tension only, it can be made much

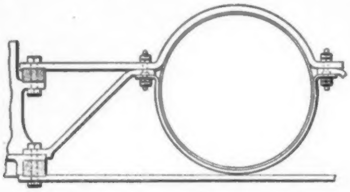


FIG. 4.—HEATER SUPPORT—APRIL, 1900.

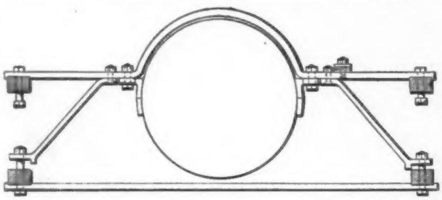


FIG. 5.—HEATER SUPPORT—APRIL, 1901.

lighter than the old form without having any effect on the action of the valve as a result of vibration.

Another change is to be found in the form of the valve itself. As first made it was short and the air to the port of the main valve passed over its edge. The rapid movement of this air down over the end of the rider tilted it and caused it not only to wear away at its ends but also to cut into the back of the main valve. The result of this double action was that it soon ceased to act as a cut-off valve, and leaked badly, practically allowing air to enter the cylinder for the whole length of the stroke. This trouble has been entirely cured by lengthening the rider and allowing the air to pass through a port cut in it instead of past its edge. Again, the valves were formerly held to the stems by nuts that were liable to work loose. Yokes of the regular locomotive type have been substituted, and the top of the valve chest has been cut away on a slope so that the stems can be slipped through the glands from the inside.

The cylinder has been shifted nearer to the end of the frame, thereby making it possible to do away with the rocker connection for the main rod. The crosshead has also been modified to the form having a removable side plate so that the gibs can be lined and adjusted with greater rapidity than was possible with the old form of U-shaped crosshead. Cast steel is also now used for the guide yoke.

The lubrication of the cylinder has also been changed by the introduction of a lubricator that acts only when the throttle is open. The old method gave a continuous feed, with the result that, after standing for a time, the first exhaust, on starting, was accompanied by a squirt of oil. The discharge of the exhaust has been changed from a shallow pan at one end of the car to an ordinary exhaust head set on the roof. A drip pipe from this leads to a small catch tank beneath the car from which the water can be drawn at the end of a trip, thus doing away with water dribbling down on the street.

Perhaps the most important changes of detail have been made in the heater. There has been no change in the principles of its action, but merely in details. It is still a tank of hot water through which the air is made to rise on its way from the storage bottles to the cylinders and after passing the reducing valve. In the early heaters the pipe leading from the storage was perforated with the perforations at the bottom and was set close to the bottom of the heater. The result was that the jets of air, impinging upon the metal of the heater tank, bored holes about ½ in. in diam. into the same. This was due to the combined contact of air and water by which a rapid oxidization was brought about. The air escaping up the sides of the pipe also

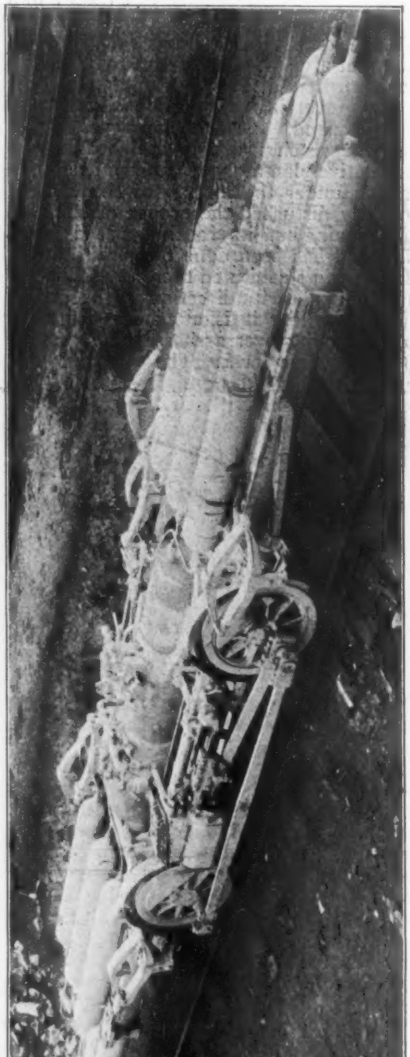
lodged on its upper surface and caused pitting at that point as well. To remedy this difficulty the perforations were turned upward and a deflecting plate placed in their line of escape so as to break up the stream and secure a proper admixture with the hot water and a corresponding amount of heating. (Fig. 2.) This was only partially successful, as much of the air would dodge past the deflector plate and escape to the cylinders unheated. In addition to this the pipe fastenings were not as secure as they might have been and one of the pipes breaking loose and wearing a groove in the bottom of the shell caused the rupture over which there was an attack of newspaper hysterics a few months ago.

The throttle pipe was also perforated at the top and was set so near the top of the heater that it was necessary to put a pocket in it in order to get it conveniently out at the curved head. This pocket served as a place of deposit for entrained water, which caused annoyance by passing into the cylinders at starting. The shell of the heater was also entirely closed with no chance for inspection or repairs.

In the new heater all of these points have been remedied. (Fig. 3.) The inlet pipe has the perforations at the bottom, but it is raised to such a distance from the shell that the incoming air will not strike the metal and to stop the pitting of the pipe itself copper has been substituted for iron as a material. The pipe has also been substantially fastened to the shell. The shell has been changed so that one head is now bolted on for easy removal and repairs, while a peep hole has been placed at each end for inspection. The throttle pipe has been made straight and is taken out through the top by means of a casting having a drip hole to allow entrained water to fall back into the tank. In the old heater all of the connections were screwed into it; in the new one they are made by means of brass flanges riveted to the shell.

Arrangements have also been made whereby, instead of using cold air for starting, as in the earlier motors, it is now heated in the same manner as that used for the regular working.

Finally, the method of carrying the heater has been greatly improved. Formerly, it was supported by a sling to which it was merely clamped, and thus held to one of the frame cross braces. (Fig. 4.) Oil and the motion of the car caused it to work back and forth to the



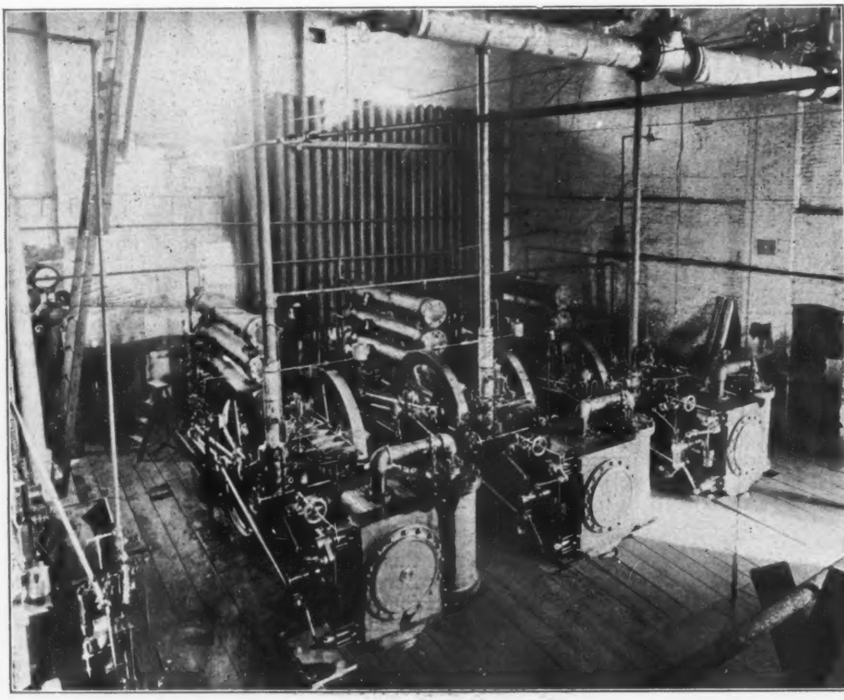
TRUCK AND STORAGE FLASKS OF THE NEW MOTOR OF THE COMPRESSED AIR CO.

detriment of the pipe connections. This will now be impossible in that there are two angle irons, riveted to the shell, by which it is bolted to the strap clamping it to the cross-brace. (Fig. 5.) Its support is further strengthened by a diagonal brace dropping down and taking hold of the lower rail of the frame.

Five of this new type of motor are now at work on the Rome City Railway at Rome, N. Y., and are running with remarkable smoothness and quietness.—*Railroad Gazette.*

Compressed Air Percussion Drill for Coal Cutting.

The Eisenbeis coal-cutter, illustrated herewith, is in use at the Reden Pit in the Neunkirchen district, Germany. It consists of a percussion drill, worked (Fig. 1 plate) by compressed air and mounted on a hydraulic tension pillar, the direction of the drill being adjusted by means of a sector. The arrangement of these parts to form a coal-cutting machine is as follows: The hydraulic pillar *s* having been fixed in position at right-angles to the sole of the seam, the semi-circular toothed sector *r* is screwed on to the sliding collar *m*, which carries a conical eye *n*, the sector being fixed parallel to the direction of the cut to be made. In the middle of the sector is an eye *o*, in which the connecting piece *p* is mounted so as to be capable of rotation; and a conical eye on this latter receives the fixing screw of the drilling machine. In a case *z*, on the toothed semi-circle of the sector is mounted an endless screw *k*, which engages in the teeth of the sector. The case *z* is screwed on to the connecting piece *p* already mentioned, so that this latter and the attached drilling machine are compelled to follow the semi-circular ro-



COMPRESSORS IN THE POWER HOUSE OF THE ROME CITY RAILROAD.

TRUCK AND STORAGE FLASKS OF THE NEW MOTOR OF THE COMPRESSED AIR CO.

tation produced by the action of the endless screw k. The work of cutting can be commenced as soon as the air pipe has been attached and the drill point put into the machine.

THE DRILLING TOOL.

The drilling tool is a cast-steel crown drill, with six radial cutters, and measures 3 in. in diameter and 8 in. in length. It is connected with the piston rod of the

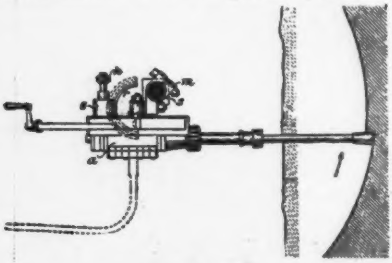
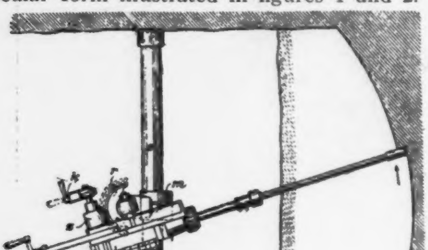


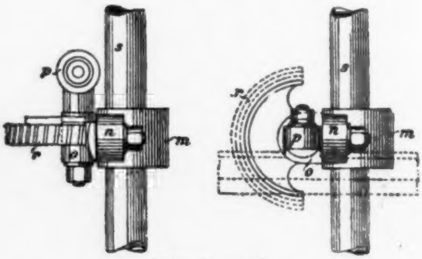
FIG. 1.

drilling machine by a tapered extension piece b and collar d. By the movement of the worm crank the blows delivered by the the percussion drill make impact on the coal at a number of successive points, so that the cut is made in the circular form illustrated in figures 1 and 2.



Eisenbeis Coal Cutter.—Fig. 2.

Without altering the position of the pillar a cut can be made 3½ to 4 metres in length, a depth of 3 m. being attainable by the addition of extension pieces to the drill. According to the hardness of the coal, the drilling machine is advanced by means of the screw e one or more turns of the crank—each of 9 mm.—each time the top or bottom of the cut is reached. At present the machine is at work in a gallery in the Kallenberg seam, the cuts being made in the middle of the seam—which is 1·80 m. thick—to a depth of 2½ m. and a breadth of 3·20 m. The machine takes half an hour to mount and dismount, and cuts a depth of 60 cm. or 2



Figs. 3 and 4

square metres of surface per hour. Two men are required to fix and dismount the machine, but one is sufficient to look after it whilst in work, the second man filling in his time by drilling five shotholes—three in the lower bank and two in the upper bank—to a depth of 2 m. each, and by clearing out the cutting with a scraper and a jet of water. The work done with this machine, says the *Zeitschrift fur Berg-, Hutten- und Salinenwesen,* was found to be equal to that performed by seven miners by hand, during the first month after its installation. The amount of air consumed at a working speed of 400 revolutions, is 0·3 cubic metres at a pressure of 5 atmospheres, that is to say, 72 cubic metres of air in making a cut of a total depth of 2·40 m. in four hours—*Boring and Drilling.*

Compressed Air Plant of the Milwaukee Harvester Co.

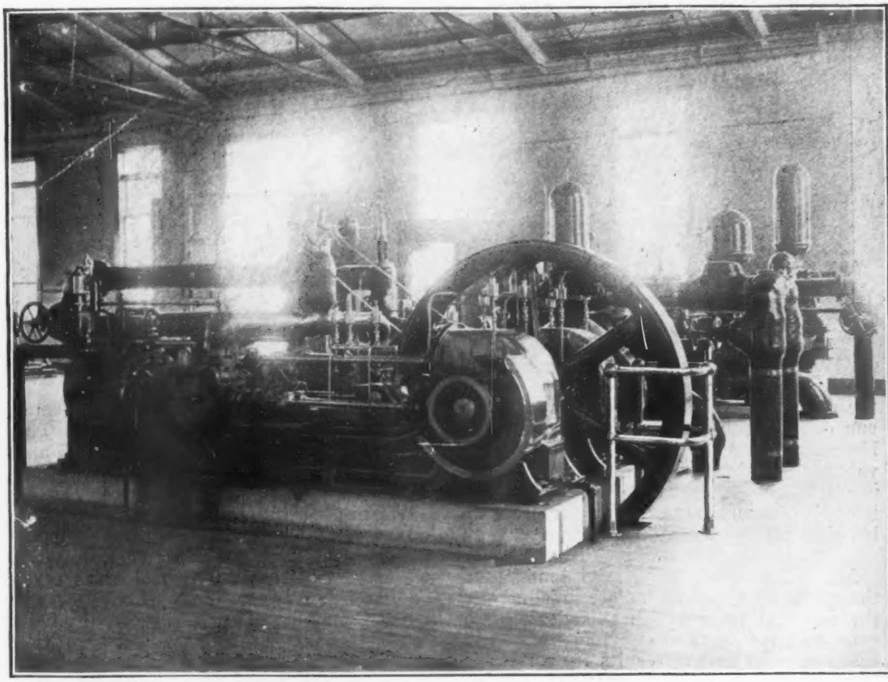
An interesting application of compressed air to general machine shop work is afforded by the plant of the Milwaukee Harvester Co., of Milwaukee, Wis., and the accompanying illustration is a view of one corner of their engine room and shows one of their compressors with a fire pump in the back ground. This machine is a 14 and 13 x 14" duplex compressor, with a rated capacity of 500 cubic feet

of free air per minute. It is fitted with Meyer's adjustable cut-off and also has a pressure and speed governor.

A second compressor, not shown in the illustration, a 5 and 5 x 6" duplex Clayton machine, completes the plant.

Both of these machines discharge into a receiver 5 feet in diameter by 10 feet long, from which is run a 4" pipe line a distance of 250 feet to the foundry. This pipe is laid underground in a 5 ft. x 6 ft. tunnel. At the foundry it discharges into a receiver 3' in dia. by 8' long. Inside the foundry building is an encircling loop of 2½ inch pipe, while from side to side across the loop is run a central pipe inclined toward the center so as to drain any moisture which may accumulate. Branches are taken from the loop to various points, and from these flexible hoses lead to 24 air hoists which are suspended to cranes on the moulding floor of the foundry. All of these hoists have a 4 ft. lift and range from 3" to 8" in diameter. In addition to the hoists, the Hanna riddling machine is being used for sifting the foundry sand.

The tunnel above mentioned also contains a second main 2" in diam. which runs to the east division of the factory where it feeds into a 2 ft. x 6 ft. receiver from which 1½" and 2" pipes are taken off to the various hoists in these buildings. Another pipe, 2½ ins. in diameter, runs to the south division, and on this circuit, in addition to the hoists, there are a number of pneumatic drills and hammers.

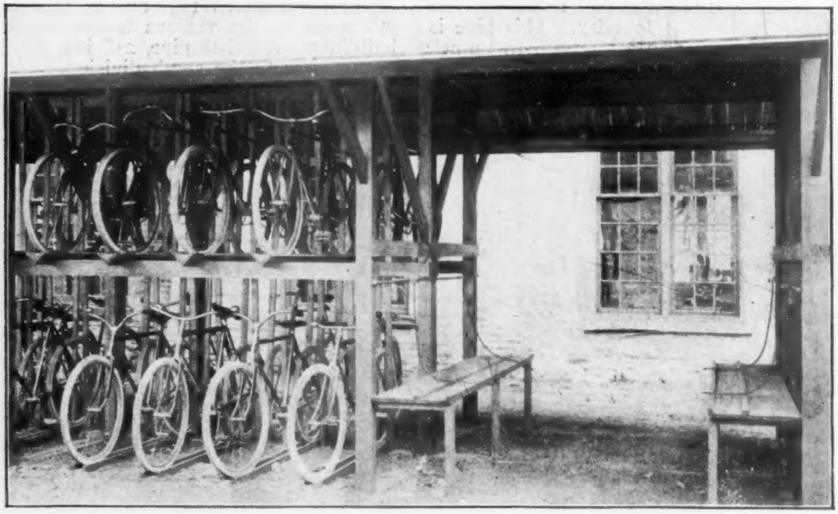


CENTRAL COMPRESSED AIR PLANT, MILWAUKEE HARVESTER CO., MILWAUKEE, WIS.

All of the buildings are equipped with air piping which is so arranged, and has its outlet so distributed that with 100 ft. length of hose, any machine or tool in the establishment can be reached or worked upon with a pneumatic tool. In the warehouses, hoists of special design are used

in piling the finished product which is in packages ranging from 200 to 500 pounds in weight.

A novel feature connected with this interesting installation are the bicycle sheds (see illustration), which are provided for the convenience of those connected with the company. There is a line of air pipe run down through these sheds with flexible connections attached at frequent intervals for inflating bicycle tires. The pressure is, of course, reduced just before entering this pipe to that necessary for properly blowing up the tires. The arrangements seem to work very satisfactorily.



BICYCLE STORAGE SHED FITTED WITH COMPRESSED AIR.

Mr. H. F. Crandell, superintendent of the company, to whom we are indebted for the material from which this description was prepared, says that while he cannot just say what saving results from the use of compressed air, the company is satisfied it is considerable, and is constantly adding appliances that are operated by it.

The Gielow Automatic Graphite Lubricator for Air Compressors.

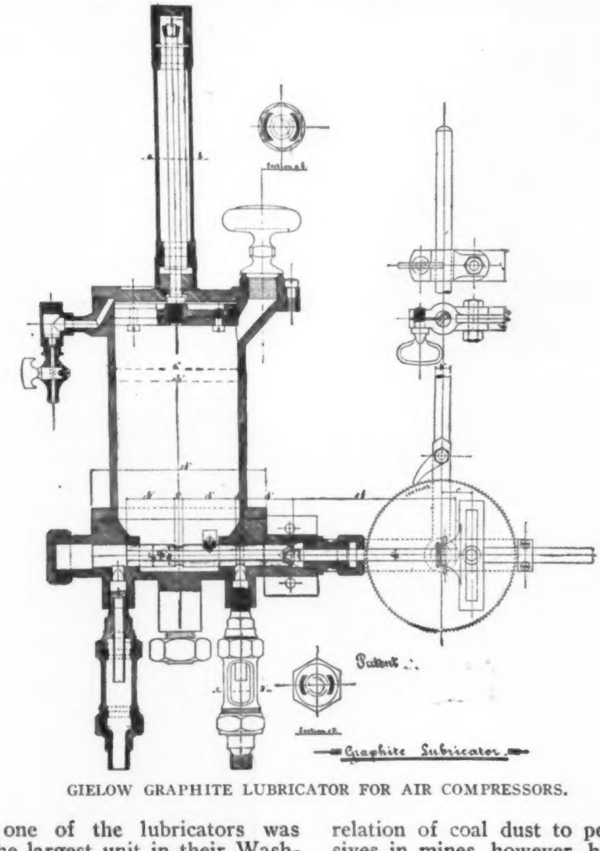
The Automatic Graphite Lubricator is designed to feed graphite into any air compressor cylinder. It is said to be absolutely reliable, and once in action requires no further attention until emptied.

There are no valves to open or close when filling. All that is necessary is to remove the lid from the cup and fill with Dixon's No. 1 Flake Graphite. The efficiency and results obtained with a constant dry graphite lubrication for air compressors is a revelation to engineers. The air compressors operate smoothly and noiselessly, especially when the temperature runs up to about 400 degrees.

When air compressors are used to force up water from a well, and are equipped with the Gielow Graphite Lubricator, the water comes from the well clear as crystal and free from any odor of oil.

The amount of graphite required to lubricate an ordinary air compressor making 60 revolutions per minute and discharging 130 cubic feet, is about three pounds per month, running full time. Previous to using graphite the same compressor used on an average about eight gallons of first-class lubricating oil per month. Furthermore, when oil was used for lubricating the valves frequently stuck and it was impossible to get rid of the odor and presence of the oil in the water. The device can be placed on any air compressor or on blowing engines, such as are used in steel and rolling milles.

The lubricator operates against high or low steam pressure. It is a sight-feed which is always clear and visible, only darkening up when the discharge of graphite is taking place, and clearing up immediately after. The feed can be regulated to the amount of graphite desired. Mr. Gielow has made several very satisfactory tests in Chicago with the result that when the lubricator was used the valves operated smoothly and quietly, and there was no groaning or cutting of cylinders. One of the tests was in the plant of the Chicago Edison Company. About two years ago one of the lubricators was placed on the largest unit in their Washington Street plant, and is giving excellent satisfaction up to this date.

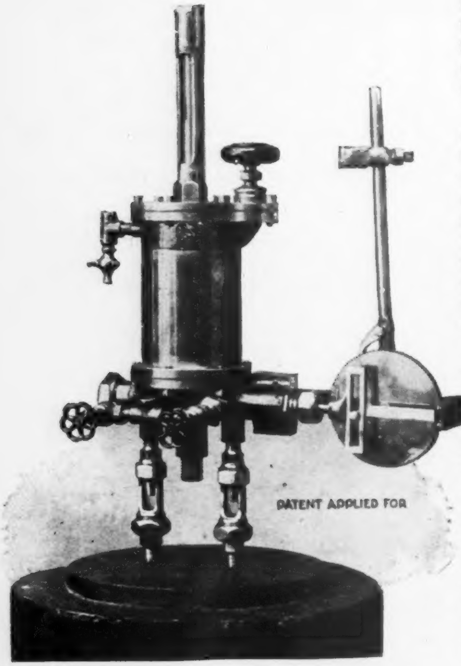


GIELOW GRAPHITE LUBRICATOR FOR AIR COMPRESSORS.

The engine on which it was placed is of the Porter-Allen type, tandem compound, condensing, 1,500 H. P., making 120 revolutions per minute, with a boiler pressure of 140 lbs. The amount of graphite used on this large unit is about three pounds in forty hours, and it can readily be seen what a great saving there is in graphite lubrication over oil lubrication.—*Graphite.*

Coal Dust Explosions in Collieries.

Explosions in collieries are generally due to the presence of firedamp, although the explosive nature of intimate mixtures of coal dust and air is well known. The relation of coal dust to permitted explosives in mines, however, has not had the attention which it deserves, and hence the paper of Mr. James Ashworth, in a recent issue of the *Colliery Guardian,* is of interest.



(See page 1558-1559.)

The direct occasion of Mr. Ashworth's paper was the explosion of coal dust in the Walthew House Colliery, due to the attempt of a fireman to break up a cog wheel with a charge of roburite, in order that it might the more readily be removed from the mine. The explosive employed in this case was one of the so-called flameless explosives, of high-class, having successfully withstood all government tests and being legalized for use in mining under well-known rules. Nevertheless, its use in this case was followed by a violent explosion, in which four men lost their lives, and the subsequent investigations established beyond question that the explosion was due to coal dust.

In examining the possible causes for the ignition of the coal dust by an explosive which had been found safe for use in the presence of firedamp, Mr. Ashworth advances a theory which appears sound, and which demands the attention of all who have to work in dusty mines. Assuming the absence of actual flame, or of firedamp, he shows that in this, and in other similar cases, the explosions were due to the ignition of the dust by the intense heat produced by the sudden air compression produced by the force of the explosive.

That heat is caused by the compression of gases is well known. Wherever air is used under pressure means must be provided to carry away the heat. The cylinders and valve chest of air compressors are water-jacketed, to prevent the heat from attaining a point which would ignite the lubricants, while in certain petroleum motors the heat of compression is relied upon entirely for the ignition of the charge every stroke.

"But we must note that it is the speed with which the air is compressed that may cause the intense heat, and not necessarily the volume which is compressed; thus in the case of an explosion in the air receiver of a compressor, the pressure of the air was only 45 pounds per square inch, and yet the heat close up to the outlet valves was 550° F., and although the oil used for lubricating had a flash point of 600° F., yet by only slightly increasing the speed of the engine two explosions occurred in the short space of eighteen months. Gas is readily given off from coal dust, and it is merely necessary to accelerate the oxida-

(See page 1558-1559.)

tion by heating the dust in contact with air to a temperature likely to be reached in compressing air to 58 pounds per square inch, to bring about the ignition of dust. Professor Bedson proved, when experimenting on coal dust after the explosion in the receiver and air pipes at Ryhope, that the ignition point of coal dust was between 291° and 320° F., and that also when coal dust was under pressure combustion was vivid and had a higher temperature than when the experiment was made under ordinary pressure."

These views receive practical confirmation in connection with the experiments made by Herr Diesel to use coal dust directly in cylinders of his internal-combustion motor. The heat of compression was found amply sufficient to ignite and maintain the coal dust in combustion without the use of any other igniting device. Diesel's experiments also showed that the temperature of ignition was materially lowered by compression, which is also in accordance with the observations upon colliery explosions.

"In connection with the Ryhope compressed air explosion there was another point which does not appear to have received any attention at the time, nor yet since, viz., that the explosion in the receiver started a wave of compression, which produced a sufficiently high temperature to cause the generation of combustible gases in the pipes in the shaft and roadway, and in this way the temperature and the pressure were increased until the wave of compression reached such a point of intensity that it caused an explosion which exerted stupendous effects at a distance of 400 yards from the receiver."

The importance of this question of possible ignition from compression should especially be considered in connection with dusty mines when it is remembered that while a temperature of about 667° C. is necessary to ignite firedamp, only 145° C. with pressure is necessary to ignite coal dust. It appears to be useless to attempt to prevent the presence of dust by sprinkling, as the presence of moisture adds to the force of the explosion.—*Engineering Magazine*.

The Use of Acetylene.

In our last issue we gave a description of a new form of acetylene mine lamp. This lamp is spoken of very highly by those who are using it and in this connection we think it worth while to call attention to the following rules for handling calcium carbide, which are advised by the National Board of Fire Underwriters:

1. Calcium carbide should be kept in water-tight metal cans, by itself, outside of any insured building, under lock and key. and where it is not exposed to the weather.

2. A regular time should be set for attending to and charging the apparatus during daylight hours only.

3. In charging generating chambers clean all residuum carefully from the containers and remove it at once from the building. Separate the unexhausted carbide, if any, from the mass and return it to the container, adding new carbide as required. Be careful never to fill the container over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine are dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

4. Whenever recharging with carbide always replenish the water supply.

5. Never deposit residuum or exhausted material in the sewer pipes or near inflammable material.

6. Water tanks and water seals must always be kept filled with clean water.

7. Never install more than the equivalent of the number of half-foot burners for which the machine is rated.

8. Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.

9. Never use a lighted match, lamp, candle, lantern or any other open light near the machine.

10. See that the entire installation is in accordance with the rules of the National Board of Fire Underwriters, a copy of which will be furnished by your insurance agent, and obtain from your contractor a written guarantee that the rules are complied with.

Note.—Failure to observe the above cautions is as liable to endanger life as property.—*The Insurance Press.*

The Doebler Pneumatic Adjustable Repair Table.

Our attention has been called to a pneumatic adjustable repair table, which should be found very useful in many places.

It consists of a stationary air cylinder, piston, piston rod and hinged swivel table, all attachable to the ordinary work bench. The table may be placed at any desirable angle between the horizontal and vertical, by means of compressed air, the movement being controlled from a four-way valve, and being on a swivel joint, may be swung to any position, thus making the work accessible at all times.

It is claimed that its use saves a considerable percentage of labor. The Chicago Pneumatic Tool Co. will give any further information desired concerning it.—*Railway and Engineering Review.*

Notes.

A compressed air locomotive has been built at the Rome Locomotive Works, at Rome, N. Y., for trial on the Brooklyn Rapid Transit Railway between Fulton Ferry and Navy street. It weighs over 25 tons and is said to have cost $35,000.

The Standard Railway Equipment Company, St. Louis, Mo., has secured a large contract for pneumatic riveters from the Russian government. Work on the company's new plant in East St. Louis is proceeding rapidly, and equipment of the most improved and thoroughly modern character will be installed.

The Westinghouse Company's Pan-American Booklet is a very striking affair, and one whose handsome cover withall does not detract from the interesting facts within. The illustrations are specially bright and clear, and it is altogether a very smart, interesting little pamphlet which gives its readers a good outline of the abilities of the Westinghouse Company's Engines.

The Miles Pneumatic Cable Carriers Booklet, gotten out by George Miles, 370 Atlanta Avenue, Boston, has come to hand with various interesting cuts illustrating their pneumatic carrier, for the transportation of merchandise and material of all kinds in any direction. This company also manufacture pneumatic elevators, cranes and power plants.

The Laidlaw-Dunn-Gordon Company, Cincinnati, Ohio, a branch of the International Steam Pump Company, is building a new foundry that is to have a capacity of 25 tons a day. The building is 100 by 200 feet and will be equipped with an overhead electric crane with a 50-foot span outside with a capacity of ten tons, and one on the inside with a capacity of 20 tons.

It is interesting to note that the work of excavating the New York Rapid Transit Company's subway tunnel, in this city, is being done entirely with regulation mining tools. Practically all the operations of mining are gone through with in the subway except the treating of the product. The telpher, ore car, drills of various sorts, steam-shovel, blasting apparatus, etc,. are all the same for the big city tunnel as for the western mine, and nearly every machine uses compressed air power.

Plans have just been completed for Machinery Hall, the first of the new buildings to be erected at Chicago with funds provided by the Armour family in the recent gift of $1,000,000 to the institution bearing their name. The first floor is to contain the forge shop, 62 x 92 feet; instructors' office, a demonstration room, locker room, lavatory and tool and supply rooms. The second floor is to be devoted to instruction in heavy machine, lathe and drill work, with offices and demonstration rooms. The third floor will contain the wood shop, with similar offices and demonstration rooms.

An account of a method whereby Mr. M. W. Travers has obtained liquid hydrogen in quantity has been given in the Physical Society "Proceedings." The apparatus consists essentially of a modified Hampson air liquefier. The hydrogen, at a pressure of 200 atmospheres, undergoes a preliminary cooling to -80 deg. Cent. in solid carbonic acid and alcohol. It is then

successively cooled by liquid air boiling under atmospheric pressure and under a pressure of 100 mm., after which it escapes from the Hampson valve, and being a sufficiently imperfect gas at the low temperature (-200 deg. Cent.) obtained by the liquid air boiling under low pressure, regenerative cooling is produced, as in the liquefaction of air by the Hampson machine, and liquid hydrogen is obtained. It is collected in a vacuum vessel specially insulated from external heat.

In connection with the hydraulic mining equipment at the Crown Mountain mine, near Dahlonega, Ga., is an interesting application of compressed air. The water is carried from a reservoir through a six-inch solid pipe to four giant nozzles, three of which operate under a pressure ot about 200 feet, at the base of the mountain, while the fourth is working near the summit; this upper giant is acting under direct pressure from a force pump located at a point some 50 feet below the level of the reservoir and driven by compressed air, generated in an air compressor placed at a convenient point some 1,500 feet from the reservoir and 1,000 feet from the mill. This compressor is so situated as to furnish air for pumping, hoisting and running drills in two working shafts which are being sunk upon known veins of value as well as for operating the force pump.

The new "Atlantics" from the Schenectady Works have the water scoop lowered and raised by an air cylinder operated from the main reservoir supply.

The ones put on some years ago had to be operated by a combination of levers and ropes; in case the scoop was not lowered and raised at the right time it would be raised by the end of the trough. This was pretty apt to disable the man at the lever.

At one time one of the roads running into Chicago had two firemen laid up with broken arms, as a result of being hit with a water scoop lever.

The later arrangement of the air cylinder lowers the scoop; the air valve is then placed in mid-position, which connects both ends of the air cylinder to the exhaust, so the scoop is free to rise if it strikes any obstruction. Another movement of the air valve turns the air in to raise the scoop.

The Eureka Pneumatic Spraying machine is adapted to a great variety of work. No application of compressed air in mechanics can show a greater saving over old methods. It is simple, strong and durable. The reservoir is made in one piece and all top parts are brazed and bottom corners are rounded to prevent sediment collecting. The mixing device will prevent settling of material. These machines are adapted for metal lacquering, for wood varnishing (in which field compressed air has not been used prior to the introduction of this machine) for painting and for japanning. It is also used for enameling and pottery glazing and in foundries for the application of oil, beer, water and all facing solutions. By simply removing the reservoir the top makes a splendid air blast to substitute for the old expensive hand bellows. The time lost in a year in opening the bellows is from 500 to 1,500 hours.

In the erection of the new East River bridge it is interesting to note that field rivets are driven by Boyer and Philadelphia pneumatic hammers, operated by a special portable compressor plant which follows the travelers on two cars. On one car is installed a 4-foot compressed air receiver tank 10 feet long and a 2-foot cylindrical gasoline tank 6 feet long and two 44 x 59-inch water tanks 7 feet high. The other car carries a 22-horse power gasoline engine and air compressor. It has a very heavy timber platform serving for an engine bed. The two axles have bearings movable vertically in cast guides through which they can be traversed by capstan headed screws. When the engine is to be used these screws are slacked off and lower the platform until the bearing is taken from the wheels to the under sides of four heavy longitudinal timbers, which then give it an extended base about 12 feet long and 7 feet wide on the tops of the ties of the railroad track on the promenade floor. When the car is to be moved the screws are turned down until the timbers are lifted about 3 inches clear of the ties and the bearing is restored to the four wheels. The compressor now installed operates six hammers and it is intended to add a duplicate plant.

The Shone system affords a means whereby sewage or other liquids can be raised automatically from any given point

to a higher point by the means of compressed air. Since its introduction in 1880, the application of this system has steadily advanced, and it is now in operation in all parts of the world. The system is applicable wherever the sewage cannot be carried by the force of gravitation to the desired point of discharge in a sanitary and satisfactory manner. It has been employed in many difficult instances and found satisfying to the utmost degree. An illustrated book of considerable interest has been issued on this subject. It explains every possible practice of the system, which is offered by the Shone Company, engineer, contractor and machinist, office and works at 445 West Forty-sixth street, Chicago. Inquirers are invited to correspond regarding any difficult proposition they may have to be solved. The book tells freely and entirely of the Shone system of sewerage and water supply and the various applications of the Shone Pneumatic Ejector.

The following should prove an interesting event: In consequence of the claim of the "Little Hercules" Drill to do 50 per cent. more work than the best makers of any English or American drills, Messrs. Stephens & Sons, patentees and makers of the "Climax Little Vixen" Rock Drills, of Carn Brea, challenge the Tuckingmill Foundry Co., and Mr. James McCulloch, the inventor of the "Little Hercules" Drill, to prove their advertised statement in public competition under any equal conditions, both underground and on surface. The competition to be held under the direction and auspices of the Mining Association and Institute of Cornwall. To this Mr. McCulloch, of Portreath, Cornwall, replied: "I positively decline a trial with any machine that has been made expressly for a contest and has not been proved of practical usefulness and durability. But as Messrs. Stephens & Son will know, I have all through been anxious to run the 'Little Hercules' against the 'Climax' or any other drill known in practice to be amongst 'the best makers of English or American drills' (to which alone the advertisement could have referred), with a view to demonstrating that my drill will perform its promises."

The construction of the so-called Rapid Transit Tunnel in New York has given rise to some comparisons between the vigor and comprehensiveness of the methods there employed and those used in the construction of the London "tuppeny tube" and the Paris Metropolitan.

In London the conditions were altogether different, and the employment of the shield in boring through the stiff London clay, especially at the depth undertaken was about the only method practicable. In Paris the leisurely progress enabled one portion of the whole system to be completed when the exposition was more than half over, and the remainder will doubtless be continued in the same manner.

In New York the work has been sublet among a number of contractors, and each is using the most effective modern mechanical appliances, and of the eleven separate contracts, eight are being executed by the aid of compressed air plants, the remainder using portable steam power plants. Overhead travellers are used in such open cuttings as permit their use, and power derricks, pumps, and all practicable mechanical appliances are being driven to their utmost capacity.

A short time ago it was our privilege to visit a tunnel in process of construction through a mountain, the object of which was to allow a river to flow into a lake from which a portion of the water supply for a growing city is taken. It is through solid rock, and as a matter of course water trickled down through the roof to the discomfort of visitors. The preliminary shaft was just about large enough to admit a horse, and, although the place was dark and forbidding, lighted only by the torch of our guide, it was not as cool as we expected, for the first fifty or seventy-five feet. We soon came to a pump that was industriously taking up water and discharging it through a pipe to the outer world, and this pump was operated by steam.

From this point onward the place was decidedly cooler, the reason for which we understood when we came to another pump, and found that it was operated by compressed air.

The exhaust from this pump escaped directly into the shaft, thus providing the necessary ventilation, as there was a current of air traveling continually towards the outer atmosphere, which made the whole place seem clean and wholesome. This was in marked contrast to the condi-

tions existing where one pipe was used to convey live steam into, and another one took exhaust steam out of the shaft.

It was a good illustration of the difference between two systems for operating pumps and drills, and the advantage of the compressed air system became more and more apparent as the length of the tunnel and the amount of machinery used was increased.

Pneumatic tools operated from a 500-horse-power Ingersoll-Sergeant compressor plant at Union Square are being used very extensively on the Holbrook, Cabot & Daly contract for Section No. 3 of the New York Rapid Transit Railway, which has about 8,000 feet of four-track steel construction. The reaming and riveting on the steel work is all done by pneumatic tools. In a comparative test on different rivets a gang of three men and a heater drove about 50 rivets in two days, and a pneumatic hammer with two men and half the time of a heater drove over 300 rivets in two and a half days. Forty per cent. of the hand rivets and only about two per cent. of the machine rivets were condemned by the inspector. The compressed air has a pressure of about 90 pounds at the power house and above 80 pounds at all places on the line. There are, in the 5-inch distribution pipe three 5 x 3-inch tees on every block, and connections are made to them for the machines, but as the tees have proved to be the weak places in the line and have caused considerable trouble by breaking, it is now believed that it would be better to have only one tee in each block, and that there would be no trouble in carrying the supply to the machines through 200 feet of 2-inch branch pipe. Originally the main air pipe was laid with screwed sleeve connections and no expansion joints, and when the weather became very hot the expansion caused many breaks at the tees which necessitated shutting off the pressure until repairs could be made. Afterward telescopic expansion sleeve joints were inserted every two blocks, since which no trouble has been experienced from breakages.

Gasoline engines are very extensively used in the United States for a variety of purposes, including such work as driving traction engines and swinging drawbridges. For all kinds of hoisting, pumping, and power purposes they are in common use. The number of styles and makes is legion, and they range from small engines for launches and automobile carriages to large double-cylinder engines for heavy work, the cylinders being placed either tandem or abreast. A majority of the engines are horizontal, but there are also many vertical engines. For pumping one arrangement is to have a pinion on the engine shaft gearing with a spur wheel with a connecting-rod to the pump crosshead, the connecting-rod being horizontal for the ordinary style of pump or vertical for a deep well pump. Air and gas compressors sometimes have the compressing cylinder placed in line with the gas engine cylinders, but in the opposite side of the crank shaft. For bridge repair work, where portable riveting hammers, etc., are largely used, many railways use a portable air-compressing plant of this kind. Hoisting and winding engines operated by gas, gasoline, or distillate engines, are in very general use, with either gearing or friction connections, and the engines are also largely used in small electric light plants. One special application is for revolving turn-tables for locomotives. Still another is for operating conveyors for loading railway ballast into railway cars. Hinged frames carry link-belts conveyors having a chain of small buckets. The ballast is shovelled into the boot or hopper—the shovels being suspended by ropes, so as to lighten the work of the men—and carried up to the head of the frame, whence it drops into the wagons.

A correspondent writing to the *American Machinist*, says:

A rather remarkable accident occurred in connection with an air hoist at our works yesterday morning. The air hoist was 6 inches diameter by 4-foot lift, and served a flanging machine. For some days past it had shown a disposition to run down when not loaded. At the time of the accident two men were making some repairs on the machine, and the hook of the hoist descended until it rested on a lug of the chuck, and then the cylinder of the hoist rose far enough to lift the ⅞-inch S-hook out of the closed link above, and then the whole hoist dropped between the two men, grazing one and slightly scratching the other, but not otherwise injuring either. It was thought that the S-hook had straightened or broken; but we found it intact. As this hook must

have been lifted at least 2½ inches to come out of the link above, we at once thought of Prof. Sweet's query of why crane hooks are made so deep inside, when a 1⅜-inch flange will hold a locomotive on the track. The answer might be that the load doesn't always rest on the hook while it is being manipulated, and that it is best to have a hook that will not disengage when the chain is slack.

But, to be frank, we would not have believed such an accident possible if we did not know all the circumstances to be exactly as stated. The S-hook had been forged under our personal direction and had been put in place by ourselves. The hoist had never been moved since, and could not have fallen without first rising sufficiently to disengage the S-hook.

The hoist was of a type in which the lowering is done by exhaust pressure, and we judge it probable that a slight leakage of the leathers had admitted air above the piston, the unbalanced pressure on the upper head due to the area of the piston rod being sufficient to lift the whole machine when the hook at the bottom of the piston rod rested against a solid object like the lug on the chuck.

The moral which we draw from the accident is: "Don't hang air hoists from open hooks." When this one goes up again it will be hung from a C-hook with the open side of the "C" closed by a plate drilled to receive the threaded ends of the "C" and held on by nuts. And the nuts will be held on by riveting the threads over.

An example of shaft excavation in rock is afforded by the shafts and tunnel work at the L. I. & Steel Co., Stony Point, for which Conrad Schroeder and Edmund A. Bartl, were the contractors.

The actual work on the shaft was commenced on May 1st; on May 20th it had been carried to a depth of 35 feet in the east shaft, and on the 26th of May the west shaft had reached a depth of 37 feet. This was through soft material and it was necessary to use 10 x 10 timber closely placed. At the depths given rocks were reached and blasting was commenced, although the compressor had not arrived.

Both shafts were sunk 15 feet, and on June 1st, air was started through 3" pipe and on July 20th, both shafts were finished, the east one being carried down 60 feet below the cribbing and the west one 54 feet.

The tunnel was started and carried 387½ feet, making a total distance of 500 feet, driven in 48 days. After finishing the rock work the tunnel was lined with brick and concreted between the brick wall and the rock. The shafts were treated in the same way. Throughout the work the hoisting was done with Mundy hoists and stiff leg derricks. With the exception of two light injuries on the hands, nobody was hurt. The superintendent of the drilling and other work was the experienced shaft and timber man, Mr. James Judge, who drove a tunnel at Niagara Falls for the paper mill several years ago.

In the work we used two Ingersoll-Sergeant "D" drills on each side. The compressor, also of Ingersoll-Sergeant make, required hardly any attention and was never out of order. The drills could have been a little larger, but they filled the bill eminently. There was about 300,000 bricks and 1,100 yards of concrete used, which was machine mixed.

The work will be finished September 14th, which is a few days ahead of contract time.

It should be noted that the location of both shafts is only about 50 feet south of the Lake Erie shore, and through the careful timbering, all caves and rush of water was prevented.

U. S. PATENTS GRANTED AUG. 1901.

Specially prepared for COMPRESSED AIR.

679,907. APPARATUS FOR REFRIGERATION OF ATMOSPHERIC AIR. Oscar P. Ostergren, New York, N. Y., assignor to the Ostergren Manufacturing Company, of New Jersey. Filed Oct. 20, 1900. Serial No. 33,681.

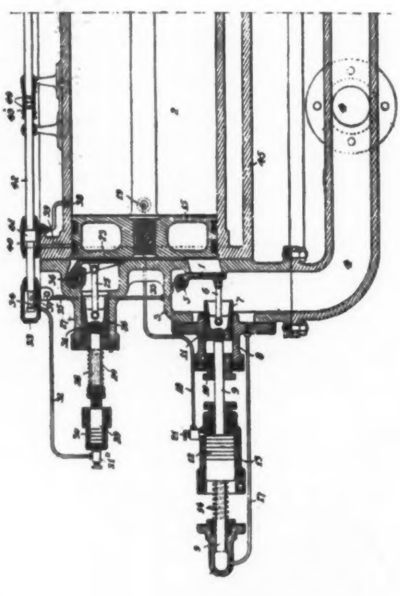
Apparatus for refrigerating compressed air, the combination of air compressing and cooling apparatus, said compressing apparatus having power in excess of the power to be expended in compressing the air, a plurality of engines for utilizing the power of the compressed air and for expanding and cooling it, said engines arranged in series and being coupled with the compressing-engine, and means for regenerating the expanding air by heat absorbed from the compressed air prior to admission into the expanding-engines, the said expanding-engines together with the prime motor adapted to continue the operations of and the expansion in the terminal engine of the series however the expansive energy of the air therein may be reduced.

679,945. AIR-BRAKE SYSTEM. Niels A. Christensen, Milwaukee, Wis. Filed July 26, 1900. Serial No. 24,864.

An air-brake system, the combination of two main reservoirs, check-valved piping therebetween, the first reservoir being in communication with a source of air-pressure and the second reservoir with the brake system, and an air-whistle communicating with said piping on the side of the check-valve toward the first reservoir.

679,955. VALVE MECHANISM FOR ENGINES FOR COMPRESSING AIR OR GASES. Zacharias W. Daw, London, England. Filed Jan. 21, 1901. Serial No. 44,160.

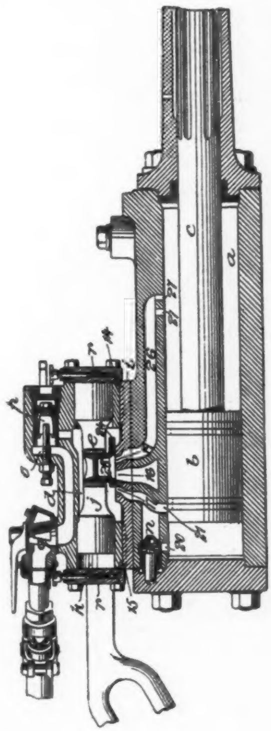
The combination of a compression-cylinder, a delivery-valve therefor, a cylinder closed at one end, a spindle connected with said valve and having a piston working in said cylinder, said piston having a passage connecting the cylinder with the receiver, whereby the piston acts as a dash-pot to cushion the opening and closing of said valve, and means



connected with said spindle for balancing the differences in pressures on the opposite side of the delivery-valve.

679,999. DIRECT-ACTING ENGINE. Henry C. Sergeant, Westfield, N. J., and William Prellwitz, Easton, Pa., assignors to the Ingersoll-Sergeant Drill Company, New York, N. Y. Filed Feb. 21, 1901. Serial No. 48,273.

A direct-acting reciprocating engine, the combination with the engine cylinder and piston, of a valve-chest, a valve and a seat therefor in said chest, and a piston in said



chest for operating said valve, said seat having independent inlet and outlet ports for communication with the same end of the engine-cylinder and having an exhaust-port, said inlet-port communicating with said cylinder near said end, and said outlet-port communicating with said cylinder at such greater distance from said end that its closure by the engine-piston before the completion of the stroke of the latter will time the reversal of the valve, all substantially as herein described.

680,028. APPARATUS FOR REGENERATING AND PURIFYING AIR. Alexandre Desgrez and Victor Balthazard, Paris, France. Filed Jan. 4, 1901. Serial No. 42,082.

680,087. ICE-MAKING APPARATUS. Edgar J. Ullrich, Colorado Springs, Colo. Filed Feb. 16, 1901. Serial No. 47,575.

680,088. ICE-MAKING APPARATUS. Edgar J. Ullrich, Colorado Springs, Colo. Filed Feb. 16, 1901. Serial No. 47,576.

An ice-making apparatus, the combination with the freezing means, of an ice-making can, a closed compressed air or gas supplying reservoir, and an air or gas discharge passage extending from the reservoir into the lower part of the can, the said can and reservoir being attached to each other and adapted to be inserted into and removed from the said freezing means together.

680,091. AIR-BRAKE CONTROLLER. John C. Wands, St. Louis, Mo. Filed Aug. 4, 1900. Serial No. 25,914.

An air-brake controller, the combination with cylinder-levers and an air-brake piston, of a movable fulcrum for one of the cylinder-levers other than that connected with the piston rod, means for causing the travel of said movable fulcrum, and a contact connection arranged in the path of the piston-rod for transmitting the excessive travel of the piston to the devices which actuate the movable fulcrum; substantially as and for the purposes specified.

680,184. AIR OR GAS EXHAUSTING PUMP. Michel Toupikof, St. Petersburg, and Charles K. Graham, Zavod, Russia. Filed Dec. 8, 1900. Serial No. 39,222.

An air or gas exhausting pump, consisting of a cylinder, a removable bottom therefor provided on its upper face with a cone-shaped portion extending within said cylinder, said bottom further provided with a vertical passage extending therethrough at the center thereof and further provided with a horizontally-extending passage communicating with said vertical passage, means for connecting said bottom to said cylinder, a piston operating in said cylinder and having its lower face made to conform to the shape of the conical-shaped portion of the bottom, said piston formed with sloping passages adapted to communicate with the vertical passage in the bottom of said cylinder, a discharge-valve carried by said piston and adapted to open and close the sloping passages therein, a valve-stem extending through said vertical passage in said bottom, a suction-valve secured to the upper end of said stem and engaging said discharge-valve, a weighted lever pivotally connected with the said bottom, a head carried by said lever and suitably connected to the lower end of said stem, and a flexible tube connected to said head and with said bottom.

680,204. MOTOR. Alfred H. Hoadley, Worcester, Mass., assignor to Pneumatic Carriage Company, New York, N. Y. Filed Jan. 24, 1899. Serial No. 703,219.

A motor-vehicle, the combination of a fluid-pressure reservoir supported in the vehicle, an impact-motor having a connection with said reservoir, a variable-speed and reversible transmitting mechanism operatively connecting said motor to a driving-wheel of the vehicle, and a controller for said mechanism.

680,330. RAILWAY AIR-BRAKE DRAIN-CUP. Peter Jacobson, Milwaukee, Wis. Filed March 5, 1901. Serial No. 49,671.

680,456. AIR-BRAKE. Maurice Hickey and Fortunatus G. Kellogg, Tacoma, Wash. Filed Feb. 2, 1901. Serial No. 45,754.

680,683. COAL-MINING MACHINE. Albert Ball, Claremont, N. H., assignor to the Sullivan Machinery Company, same place and Chicago, Ill. Filed Aug. 21, 1897. Serial No. 649,014.

A mining-machine, the combination with a suitable frame of a reciprocating cutter-bar and its operating mechanism mounted to swing in a vertical plane, a supporting-bar for the cutter-bar, means for adjustably clamping said supporting-bar to said cutter-bar-operating mechanism, so as to permit longitudinal adjustment of said supporting-bar, and removable truss-rods connected to said supporting-bar.

680,697. PNEUMATIC-DESPATCH-TUBE APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Nov. 27, 1899. Serial No. 738,329.

680,698. PNEUMATIC-DESPATCH APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Nov. 27, 1899. Serial No. 738,330.

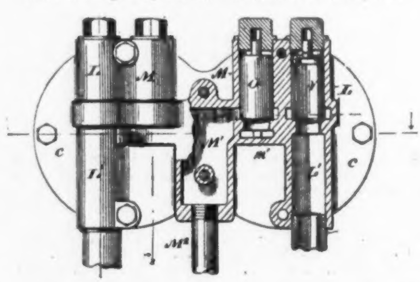
680,699. PNEUMATIC-DESPATCH APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Nov. 27, 1899. Serial No. 738,331.

680,700. PNEUMATIC-DESPATCH APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Jan. 19, 1900. Serial No. 1,975.

680,761. PNEUMATIC STRAW-STACKER. Charles W. Burton and Edward M. Burton, Royal Center, Ind. Filed June 13, 1901. Serial No. 64,414.

680,776. PNEUMATIC TIRE. William E. Hoyle, Providence, R. I., assignor to Rudolph F. Morse and Samuel H. Boardman, same place. Filed Dec. 8, 1900. Serial No. 39,119.

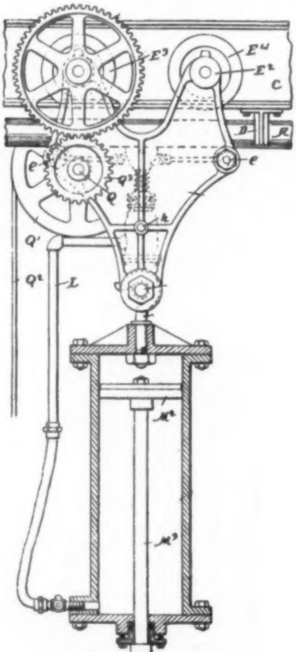
680,842. VALVE FOR COMPRESSORS. Niels A. Christensen, Milwaukee, Wis. Filed July 18, 1898. Serial No. 686,266.



A compressor the combination with a cylinder having a cylindrical valve-chamber com-

municating through a port above the valve-seat with the interior of the cylinder and below said seat with an inlet passage or opening, of a hollow imperforate cylindrical suction-valve closed at both ends and loosely fitting and nearly filling said chamber, substantially as and for the purposes set forth.

680,849. APPARATUS FOR SUPPLYING COMPRESSED AIR TO MOVABLE MOTORS AND HOISTS. William M. Farrar, Hoboken, N. J. Filed Sept. 12, 1900. Serial No. 29,771.



In combination, an I-beam acting as a supporting-track, a pipe attached to the lower edge of the I-beam, said pipe having a slot, a carriage having wheels traveling on the I-beam, a box carrying a wheel projecting into the slot, a valve-strip normally closing the slot, lifted by the wheel, anti-friction-wheels carried by the box, a pipe depending from the box, a chamber with which the pipe communicates, a suitable packing-ring for the pipe, for yielding and holding the wheel in the slot and for regulating the tension on the packing-ring, a motor supported by the carriage and means for supplying the fluid from the pipe to the motor.

680,852. VALVE DEVICE. Robert F. Foster, Brooklyn, N. Y., assignor to Hamilton-Foster Fog-Signal Company, Ridgefield, Conn. Filed Dec. 27, 1900. Serial No. 41,279.

680,951. HYDRAULIC AIR-COMPRESSOR. Addison G. Waterhouse, Springfield Township, Pa. Filed Jan. 31, 1901. Serial No. 45,425.

681,011. ROCK-DRILL. Otto G. Worsley, Newark, Ill. Filed Feb. 23, 1901. Serial No. 48,600.

A rock-drill, in combination, a chambered stock having a lateral aperture, a cutter housed within the chamber and projecting through the aperture, and a slide for closing the passage between the lower wall of the aperture and the lower edge of the cutter when the cutter is in its retracted position.

681,013. PNEUMATIC - DESPATCH - TUBE APPARATUS. Martin Barri, Lowell, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J. Filed Aug. 25, 1900. Serial No. 28,008.

An apparatus of the character described, a despatch-tube, a source of compressed air, a valve normally open for closing the despatch-tube after the insertion of the carrier, mechanism for closing said valve, a valve controlling the supply of compressed air to the despatch-tube, means for holding said valve normally closed, mechanism operated by compressed air for opening said air-supply-controlling valve, means for holding said air-supply-controlling valve open, mechanism operated by compressed air to actuate said valve-holding means to release said air-supply-controlling valve to allow it to close, and adjustable means for regulating the movement of said releasing mechanism.

681,014. PNEUMATIC-DESPATCH APPARATUS. Martin Barri, Lowell, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J. Filed May 9, 1901. Serial No. 59,435.

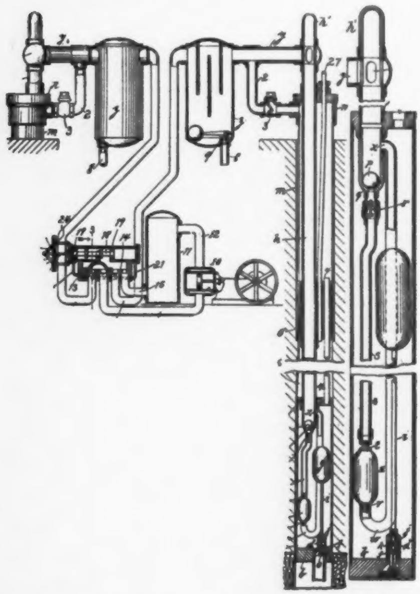
681,041. PNEUMATIC-DESPATCH-TUBE CARRIER. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Oct. 8, 1900. Serial No. 32,328.

681,067. CONNECTION-PIECE FOR PNEUMATIC-TIRE VALVES. James F. Morrissey, Springfield, Mass., assignor to Erastus N. Parker, same place. Filed June 18, 1901. Serial No. 65,009.

681,078. PNEUMATIC-TUBE TERMINAL. William H. Sheppard, New York, N. Y., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed March 3, 1899. Serial No. 707,628.

681,108. PNEUMATIC-DESPATCH-TUBE APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Dec. 21, 1899. Serial No. 741,112.

681,216. PNEUMATIC LIQUID-RAISING APPARATUS. Edward Gray, Bradford, Pa., assignor of one-half to Philo C. Blaisdell, same place. Filed March 23, 1900. Serial No. 9,884.



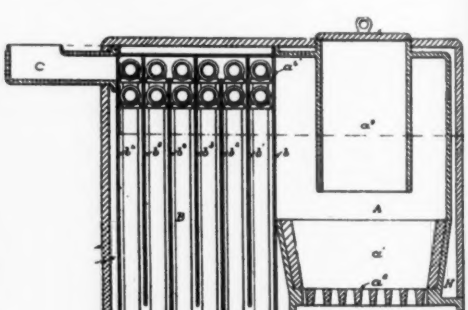
Fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited quantities, an eduction-pipe, means for successively expelling the liquid charges therethrough by pneumatic pressure applied under the liquid column, part of which means comprises a pneumatic chamber in connection with the service of compressed air and affording ejecting force by expansive action of its contents after the supply is shut off, and a follower in said eduction-pipe between the air column and the liquid column.

681,221. SUBMARINE BOAT. John P. Holland, Newark, N. J., assignor to Electric Boat Company, of New Jersey. Filed Sept. 27, 1900. Serial No. 31,221.

681,222. SUBMARINE VESSEL. John P. Holland, Newark, N. J., assignor to Electric Boat Company, of New Jersey. Filed Oct. 3, 1900. Serial No. 31,875.

681,357. APPARATUS FOR PREHEATING AND MOISTENING COMPRESSED AIR. William O. Webber, Boston, Mass., assignor to Walter C. Carr, New York, N. Y. Filed Aug. 29, 1900. Serial No. 28,483.

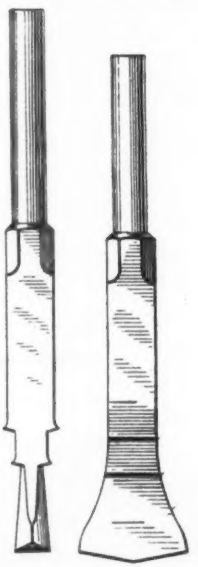
An apparatus for the progressive moisten-



ing and heating of compressed air, the combination with a compressed air passage, of a furnace having a series of chambers arranged at successive points nearer to said furnace, air-circulating pipes extending through said chambers, and a moistening apparatus consisting of a series of discharge-nozzles, each of which opens into a circulating-pipe, substantially as described.

681,358. PROCESS OF PREHEATING AND MOISTENING COMPRESSED AIR, &c. William O. Webber, Boston, Mass., assignor to Walter C. Carr, New York, N. Y. Filed Nov. 20, 1900. Serial No. 37,172.

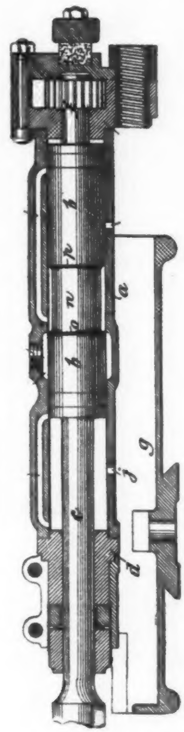
681,381. CUTTER FOR ROCK-DRILLS. Jacob Wallace, D. Frank Irwin, and Joseph H. Smith, Plymouth, Ohio, assignors to the Wallwinith Manufacturing Co., of Ohio. Filed Nov. 12, 1900. Serial No. 36,194.



An improved bit or cutter for rock-drills formed with an expanding lead or striking end centrally thickened at its base, said cutter being further provided upon its sides above said lead and parallel to the greater diameter of the same, with graduated shoulders or offsets, the under surfaces of which are upwardly inclined, substantially as and for the purposes set forth.

681,428. VALVELESS ROCK-DRILL. Robert L. Ambrose, Tarrytown, N. Y., assignor to Rand Drill Company, New York, N. Y. Filed Nov. 15, 1900. Serial No. 36,633.

A valveless rock-drill, the combination with a cylinder having separate admission and exhaust ports for each end of the cylinder and a common inlet-port, of a piston, having a reduced central portion and adapted to control the said ports, the said ports being so located with respect to each other and to the piston that during a rearward stroke of the piston, admission cut-off at the forward end is substantially simultaneous with exhaust-

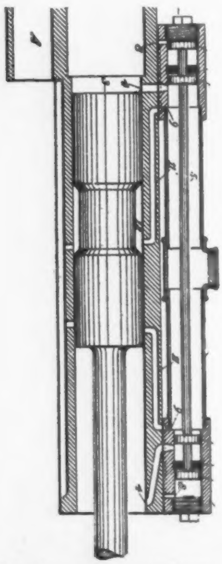


closure at the rear end, but is earlier with respect to a full stroke of the piston than the corresponding point of admission cut-off at the rear end during a forward stroke.

681,626. PNEUMATIC INDICATOR SYSTEM. William B. Cowles, Cleveland, Ohio, assignor to the Long Arm System Company, same place. Filed May 28, 1901. Serial No. 62,294.

A pneumatic system of the character described, the combination with a plurality of doors, hatches or other like barriers, of a source of fluid-pressure, mechanism for operating said barriers operated by said source of fluid-pressure, valve mechanism operated by the motion of the barrier at a predetermined part of its travel, a pneumatic or fluid-pressure indicator, and connections between said source of fluid-pressure, said valve mechanism, and said indicator, substantially as described.

681,504. ROCK-DRILL. Charley Hultquist, Jerome, Ariz. Filed April 13, 1901. Serial No. 55,645.



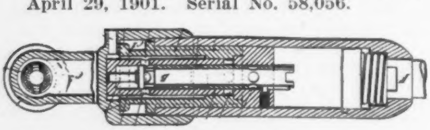
The combination in a rock-drill of a cylinder, a drill-piston reciprocable therein, a steam-chest having a valve-chamber at each end and a steam-entrance intermediate of said chambers and common to both chambers, ports connecting each valve-chamber directly with the cylinder, a valve-rod and a double valve at each end thereof, said valves operating in their chambers and controlling the admission of steam to and the exhaust from the cylinder.

681,534. TERMINAL DEVICE FOR PNEUMATIC-DESPATCH TUBE SYSTEMS. Edmond A. Fordyce, Chicago, Ill., assignor to Arthur S. Temple, trustee, Boston, Mass. Filed July 10, 1901. Serial No. 67,702.

681,597. AIR-PUMP. Edward Walther, Washington, Iowa. Filed April 23, 1901. Serial No. 57,062.

682,408. CARRIER FOR PNEUMATIC-DESPATCH TUBES. Hugo W. Forslund, Chicago, Ill., assignor to the Lake Street Manufacturing Company, same place. Filed Sept. 15, 1899. Serial No. 730,547.

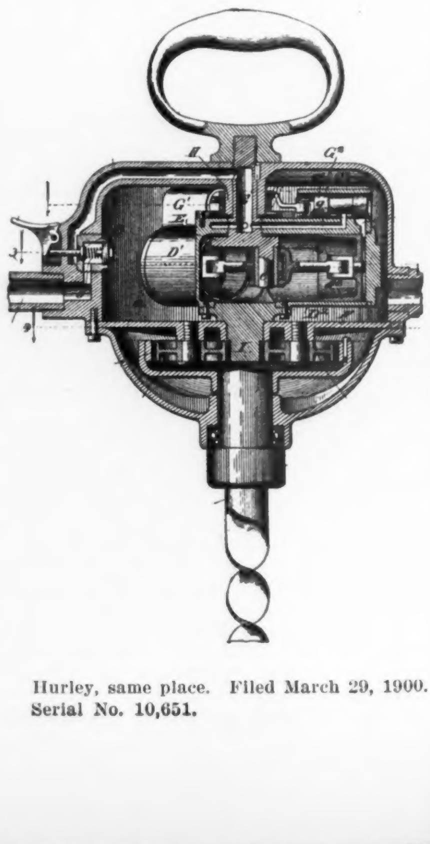
682,492. FLUID-PRESSURE HAMMER. Walter Payton, Richmond, England. Filed April 29, 1901. Serial No. 58,056.



A portable fluid-pressure hammer, the combination with a casing formed of two detachable parts and constituting the working cylinder, said casing having a handle at one end and a tool-holder at the other end, of a reciprocating piston constituting the hammer proper and consisting of a block having two external diameters and a central longitudinal hole extending completely therethrough, of a sliding tubular tappet-valve located in said central longitudinal hole and of a push-piece located contiguous to one end of said tubular valve and projecting from one end of the piston; said valve and piston being provided with ports adapted to be opened and closed by the changes in position of the valve relatively to the piston, substantially as described.

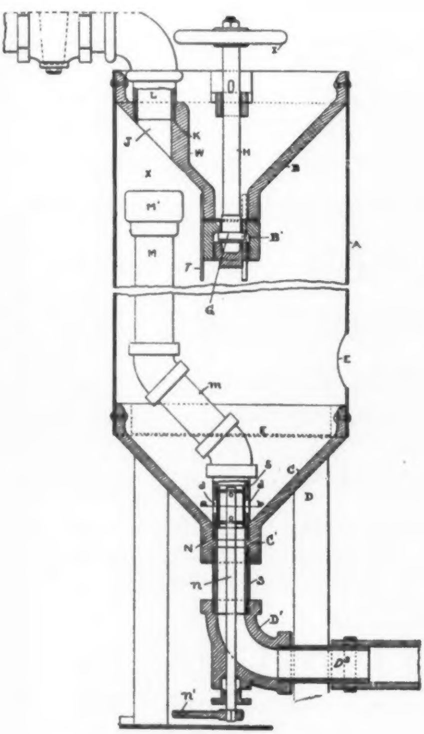
682,499. TRIPLE VALVE. John W. Shafer, Chicago, Ill., assignor of one-half to Belle Bradrick, same place. Filed Feb. 11, 1901. Serial No. 46,928.

682,555. DRILL. Henry J. Kimman, Chicago, Ill., assignor of one-half to Edward N. Hurley, same place. Filed March 29, 1900. Serial No. 10,651.



A machine of the class described, the combination of a cylinder-frame provided witn a plurality of fluid-pressure cylinders having a fixed relation to each other arranged to rotate around a common central point and with a valve-chamber open at both ends, arranged in line with each of the fluid-pressure cylinders, a reciprocating valve in each of the valve-chambers, and a fixed eccentric connected with each and all reciprocating valves, whereby as the cylinder frame is rotated the valves are given their proper motion, substantially as described.

682,579. MIXER FOR SAND-BLAST APPARATUS. Ambrose G. Warren, Philadelphia, Pa., assignor of one-half to J. W. Paxson Company, same place. Filed Feb. 28, 1901. Serial No. 49,257.



A sand-blast apparatus the combination with a casing adapted to receive and contain sand and fluid-pressure, a discharge-outlet therein, a combining-tube supported by and opening into said discharge-outlet and extending upward into the interior of the casing, radially-arranged ports or passages in said upper portion of tne combining-tube into which sand is adapted to be forced by gravity and pressure directly from the casing, and a secondary air-inlet within the casing communicating by a closed passage directly with the mouth of the combining-tube and adapted to deflect a portion of the fluid-pressure within the casing, above the sand-line, into said combining-tube above the radial sand ports or passages therein.

Visitors to New York should take advantage of some spare moments and attend one or more of the very entertaining little plays given at any of the four theatres belonging to F. F. Proctor. Each of these theatres has its own stock company, and vaudeville is introduced between the acts. F. F. Proctor's theatres are on Twenty-third street, Broadway and Twenty-eighth street, Fifty-eighth street and Third avenue and 125th street.